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DISEASES OF THE EYE.

A HANDBOOK

OF THE

DISEASES OF THE EYE

AND THEIR

TREATMENT

BY

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TO OPHTHALMOLOGY.

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PREFACE TO THE NINTH EDITION.

THIS work now appears under joint authorship. In preparing the present edition, the endeavour has again been to keep the book abreast of modern ophthalmology—in so far as is possible, without adding to its size—by discarding what had become obsolete, and by introducing important new developments. That there are more pages in this edition results, mainly, from the greater number of illustrations contained in it, being sixty more than in the previous edition. Moreover, in compliance with very generally expressed wishes, a chapter on elementary optics has been introduced, and the optical structure of the eye, refraction and accommodation, and the theory of the ophthalmoscope have been treated of with more completeness. Chapter v. now contains an account of the bacteriology of conjunctivitis; chapter xviii. has been improved, and a description of heterophoria added; and many other alterations have been made throughout the book.

H. R. S.
L. W.

DUBLIN,
January 1907.

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TO THE STUDENT.

The student may at first omit the portions printed in small type, and those marked with an asterisk, including the whole of chapter xx. With these exceptions he should carefully read chapters i., ii., iii., and iv., immediately on joining the ophthalmic hospital or department.

DISEASES OF THE EYE.

CHAPTER I.

ELEMENTARY OPTICS.

§1. THE light from a luminous point travels in all directions in diverging straight lines which are called rays. The angle between the outermost rays which pass through an aperture (A B, Fig. 1), or fall on a given surface, is the measure of the divergence of the rays. This divergence diminishes as the distance of the luminous point, from the surface on which the light falls, increases (Fig. 1), until it finally becomes so small that the rays may be considered to be parallel. In a strict mathematical sense, rays can only be parallel when the luminous point from which they come is at an infinite distance; but, in ophthalmological practice, rays proceeding from any point at a distance of 6 metres, or more, from the eye may be regarded as parallel when they reach the pupil. Under natural conditions, rays entering the eye are either divergent (objects nearer the pupil than 6 m.) or parallel; but they are never convergent, unless rendered so by artificial means (lenses, mirrors).

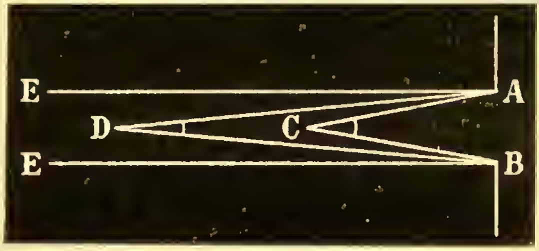

FIG. 1. The rays from D, which is further from A B than C, have a smaller angle of divergence. The parallel rays, E E, are supposed to come from a point infinitely distant.

§2. When light falls on an opaque object, some of the rays are absorbed, some are reflected in an irregular or diffuse manner, rendering the object visible, while others are regularly reflected according to the amount of polish on the surface of the object, but none pass through it. When the object is transparent, the majority of the rays pass through, but are bent or *refracted*.

§3. **Refraction**, then, is the deviation which a ray of light undergoes when it passes from one homogeneous transparent medium into another of different density. The only rays which are not refracted are those perpendicular to the surface (A B, Fig. 2). All others are deviated towards the perpendicular when passing from a rarer into a denser medium, and away from the perpendicular when travelling in the opposite direction. In Fig. 2 the incident ray, I H, travelling from the rarer medium (air) into the denser medium (glass), is bent towards the perpendicular, P, in the direction H R, and would continue in this path as long as it remained in the denser medium; i is the angle of incidence and r the angle of refraction. If the ray R H were to pass back in the opposite direction from the glass into air, it would be deviated away from the perpendicular, in the direction H I. The path of the ray, therefore, is the same in either direction.

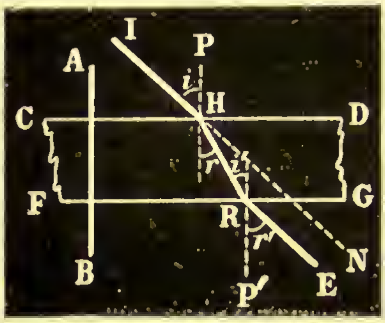

FIG. 2.—Refraction at a plane surface. The surfaces C D and F G being parallel, the emergent R E is parallel to the incident ray I H.

§4. **Index of Refraction.**—The more dense a medium is, the greater is its refractive power. The relative refractive power of a given substance is called the index of refraction of the substance, air being generally taken as the unit. A medium, therefore, having a greater density than air will have, as index, a number greater than unity; the index of crown glass, for instance, is 1·5. The cornea and the vitreous humour have the same index as water, namely 1·33, while that of the crystalline lens, as a whole, is 1·43. The refractive power depends on the difference between the indices of the two media; for example, in the eye the cornea has a greater effect than the lens, although it has a lower refractive index than the latter, because the difference between air and the cornea is greater than that between the media (aqueous and vitreous) and the lens which lies in them,

§5. **Plane Parallel Surfaces (Plane Glass)** bounding a transparent medium cause merely a lateral displacement of the rays without changing their direction, if the first and last media are the same. In Fig. 2, C D F G may be taken to represent a piece of glass with parallel sides C D and F G, with air on each side. When the emergent ray, R E, passes out again into the air it is refracted away from the perpendicular, P′, and as the angles i and r' are equal, and the perpendiculars P and P′ are parallel, the ray E R is parallel to its original path I H, and suffers only a lateral displacement, which increases with the thickness of the plate. But the relative direction of the rays is not changed; they retain the parallelism, divergence, or convergence, which they possessed before their passage through the plate; hence no images are formed by plane glass, and objects seen through it are unaltered in size or shape.

PRISMS.

§6. **Prisms** are refractive media limited by plane surfaces which are inclined at an angle, as in Fig. 3. The thin edge is called the Apex, *a* is the Refracting Angle, while the thick part opposite the apex is the base. In passing through a prism a ray of light undergoes a double refraction towards the base. The ray O is deflected towards the perpendicular on entering the prism, and away from it on passing into the air at the side B A, the deviation being towards the base in each case.

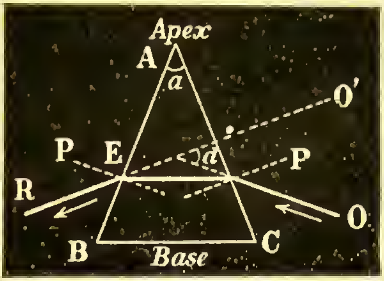

FIG. 3.—Refraction by a prism. The rays from O are displaced towards the base, but O appears to an observer at R to be displaced towards the apex.

An object seen through a prism seems to be displaced towards the apex; for example, an eye placed at R receives the ray E R coming from O, and imagines it to be at O′ in the prolongation of R E. The deviation which the ray O has undergone is shown by the angle *d* (angle of deviation). In prisms made of crown glass, with an index of refraction of 1·5, the angle of deviation is equal to half the angle of the prisms. Fig. 4 shows that, as in plane glass, the relation of the rays to each other are unaltered in their passage through a prism.

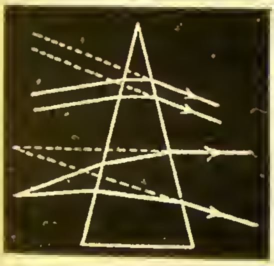

FIG. 4.—Showing parallelism or divergence of rays unaltered by their passage through a prism.

§7. Numbering of Prisms.—Prisms are numbered according to the size of the refracting angle (*a*, Fig. 3), which is expressed in degrees; we speak of prisms of 1°, 2°, etc.

This method of numeration is not quite accurate, because the deviation depends, not only on the angle of the prism, but also on the refractive index of the glass composing it; hence, two prisms having the same number will not produce the same amount of deviation, or be of the same strength, if the kinds of glass of which they are made have different refractive powers. It has, therefore, been proposed to number them according to the angle of deviation (*d*, Fig. 3), expressed either in Centrads or in Prism-Dioptres, a centrad being a deviation (*d*, Fig. 5), the arc (C T) of which is $\frac{1}{100}$ of the radius, while in the prism-dioptre it is the tangent (A T) which is the $\frac{1}{100}$ of the radius (Fig. 5). The three methods are, however, equivalent for all practical purposes. The simplest plan would be to indicate the deviation, and not the angle of the prism, in degrees.

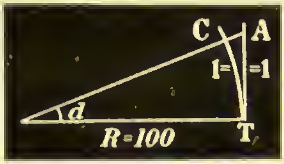

FIG. 5.—One centrad $= \frac{CT}{R}$.
One prism dioptre $\frac{AT}{R}$.

§8. Recognition of a Prism and the Base-apex Line.—Prisms used in ophthalmic practice are usually cut round for convenience of placing in trial frames, but the thick base and thin apex are sufficient to distinguish them from lenses or plane glass. In weak prisms this is not so evident, but they can always be recognised by the displacement which they cause when an object is seen through them, by quickly putting the prism up before one eye, the other being closed, or if the prism be rotated before the eye, an object seen through it will be observed to move in a circle, following the displacement of the apex. Figs. 6 & 7 show a simple method of detecting the displacement, and at the same time of ascertaining the exact position of the apex and base. The prism is held at a short distance from the eye opposite two crossed lines, vertical and horizontal (the bars of a window-sash, say), so that they can be seen outside the glass as well as through it. If, as in Fig. 6, the apex and base, A, and B, are exactly horizontal, then the portion of the vertical line C D seen through the glass

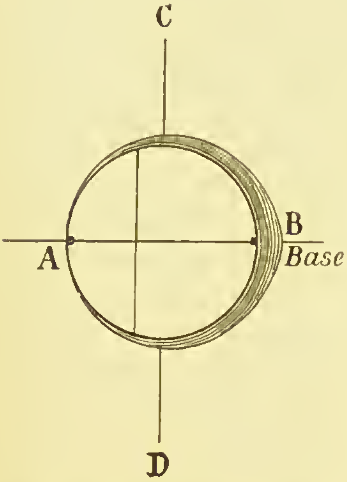

FIG. 6.—Prism horizontal, vertical line only displaced.

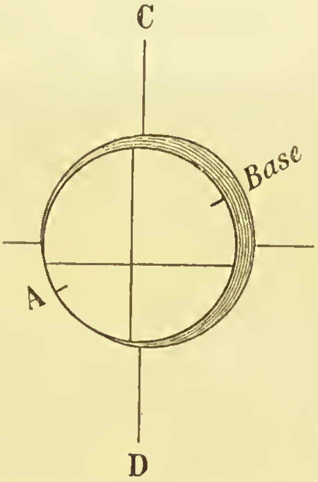

FIG. 7.—Prism held obliquely, both vertical and horizontal lines displaced.

will alone be displaced towards the apex ; but if the prism be oblique both lines will be displaced as in Fig. 7.

§9. **Effect of a Prism on Binocular Vision.**—When a prism is placed before one eye, both eyes being open, the immediate effect is to cause double vision or diplopia, which either persists, or is overcome by an effort of one of the orbital muscles. In fig. 8, the image of the object, O, falls on the macula lutea, M, in the left eye (L), but instead of falling on the macula, M, in the right eye (R) it is displaced by the prism, towards the base of which it is refracted, to a point B on the retina, which is not physiologically identical with M in the left eye, and O now appears to the right eye to be at O′, in the prolongation of B P, and the patient sees two images, one with each eye. An unconscious effort is then made by the patient to bring the macula, M, into the position B.

This is accomplished by the action of the Ext. Rectus (R E), and thus single vision is again obtained. If desired, by increasing the strength of the prism until the diplopia can no longer be overcome, the strength of the muscle, in this instance the Ext. Rectus, can be estimated. It will be observed also, that when, in order to correct the diplopia, the axis of the eye has moved into the position P B, the convergence of the eyes is diminished, and therefore the effort of the internal rectus muscle must to a certain extent be relieved. From this it follows, that the muscle towards the apex of the prism is brought into action, while the muscle towards the base is relieved. The rotatory prism, composed of two prisms of equal strength, in contact, and rotating in opposite directions, is a useful instrument for measuring purposes, as by its aid values of from 0° up to the strength of both prisms combined can be obtained gradually. Maddox's double prism is also very convenient for producing diplopia (see Latent Deviations, chap. xviii.).

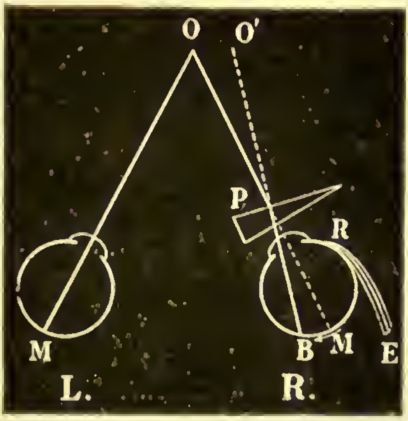

FIG. 8.—Binocular diplopia produced by a prism.

§10. **Uses of Prisms.**—1. By the production of diplopia, prisms can be used, (*a*) to test the strength of muscles, (*b*) to detect latent deviations or insufficiencies of muscles, (*c*) to strengthen weak muscles by exercise, (*d*) to test binocular vision, (*e*) to detect feigned blindness of one eye. 2. For the purpose of correcting or measuring the diplopia in paralysis, or insufficiencies of orbital muscles.

§11. **Prescribing of Prisms.**—In practice prisms of more than four degrees can rarely be worn by patients, owing chiefly to the weight and colour effects of higher numbers. The position of a prism placed before an eye is indicated by reference to its base, *e.g.*, Pr. 3° base up, down, in, or out, as the case may be.

LENSES.

§12. A lens is a portion of a transparent refracting medium bounded by two surfaces, one or both of which are curved. It may be spherical, or cylindrical, or it may be compound, that is to say spherical on one surface and cylindrical on the other.

§13. **Spherical Lenses** are bounded by spherical surfaces, and therefore their action is the same in all meridians; they are either convex or concave. Convex spherical lenses may be regarded as composed of prisms with their bases together (fig. 9) and are thicker in the centre. They converge parallel rays of light, and bring them to a point or focus. Concave lenses, on the other hand, are like prisms with their apices together (Fig. 10), and are thinner in the centre. They cause parallel rays of light to diverge. Convex lenses are positive, and are indicated by the sign + (plus). Concave lenses are negative, and marked with the sign — (minus). The former placed in front of the eye add to its refractive power, the latter diminish it. Fig. 11 shows the different kinds of spherical lenses in use. In

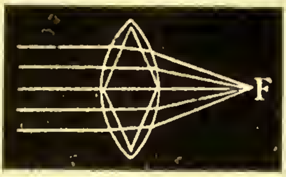

FIG. 9.—Convergent effect of a convex or + lens. F, principal focus.

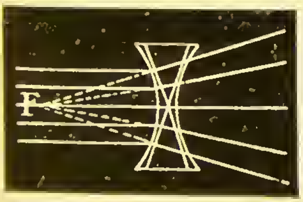

FIG. 10.—Divergent effect of a concave or – lens. F, principal focus.

the convex meniscus, the convex surface has a shorter radius of curvature than the concave; whereas in the concave meniscus, the concave surface has the smaller curve. Meniscus lenses are also called periscopic (*περί, around*; *σκοπεῖν, to look*), because (with the concave surface towards the eye) they produce less distortion towards their edges, and consequently permit a greater excursion of the eye.

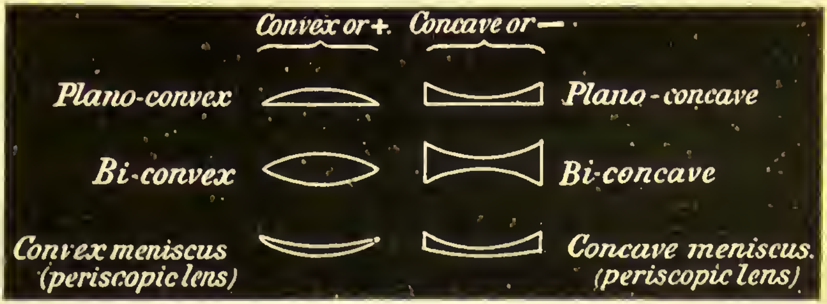
Convex or +.
Concave or —
Plano-convex
Plano-concave
Bi-convex
Bi-concave
Convex meniscus (periscopic lens)
Concave meniscus. (periscopic lens)

FIG. 11.—Different forms of spherical lenses.

§14. **Axes of Spherical Lenses.**—The Principal Axis of a spherical lens (P A, Fig. 12) is the line joining the centres of curvature of the surfaces, and the point O in the centre of the lenses on the principal axis is known as the Optical Centre. Any ray passing through the optical centre, except along the principal axis, is called a Secondary Axis, and it emerges parallel to its original direction (N E is parallel to S S′). In thin lenses the slight displacement may be neglected, and the secondary axes may be considered to pass through the optical centre without any deviation. These statements apply to both convex and concave lenses.

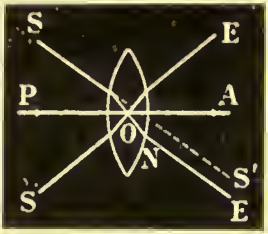

FIG. 12.—Primary and secondary axes of a lens.

§15. **Principal Focus of Convex Spherical Lenses.**—The point to which parallel rays of light converge after passage through a convex lens is called the Principal Focus of the lens, and the distance of this point from the lens is the focal length (Fig. 13). Rays of light diverging from the principal focus pass out parallel on the other side of the lens. Rays (*a c*, Fig. 13,) parallel to the principal axis, have their focus on this axis, while those which are parallel to a secondary axis, (A S, Fig. 14,) are brought to a focus on the secondary axis at a point (S), where it cuts the perpendicular line passing through the principal focus (principal focal plane). The stronger the lens the more the rays are refracted, and therefore the shorter is the focal length (Fig. 15).

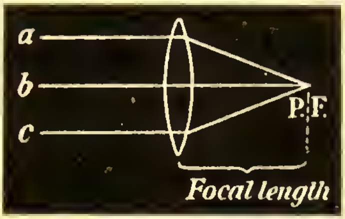

FIG. 13.—Principal focus (P F) and focal length of a lens.

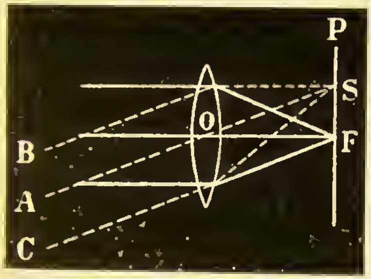

FIG. 14.—Rays A and B, parallel to the secondary axis A S, unite in the focal plane F P at S.

§16. **Conjugate Foci** are foci which are so related that rays from one of them pass to the other and vice versa. For instance, the conjugate focus of parallel rays (or infinity) is the principal focus, and the latter is again the conjugate focus of infinity.

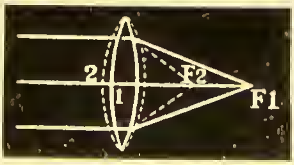

FIG. 15.—The stronger lens (2) has a shorter focus, F 2.

§17. **Real, or Positive Conjugate Focus of a Convex Lens.**—We have now to consider what happens to rays which diverge from points on either side of the principal focus; namely, points further from, or nearer to, the lens than the principal focus. In Fig. 16 the rays from the point 1 further from the lens than the principal focus F, converge to 1′, beyond F, on the other side of the lens, and form an image there, which is real and can be received on a screen. When the point from which the rays diverge approaches nearer to F, say at 2, then the conjugate focus moves further away to 2′, until, when the point reaches the principal focus F, the conjugate focus has moved away to infinity, and the rays are parallel. It will be noticed that in this case the conjugate foci are on opposite sides of the lens, but that they move in the same direction.

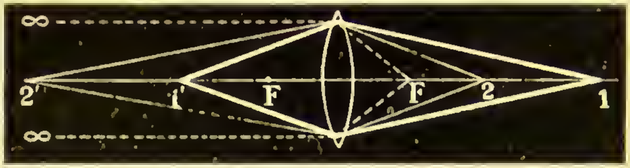

FIG. 16.—Real, or positive, conjugate foci of a convex lens.

§18. **Virtual, or Negative, Focus of a Convex Lens.**—When rays proceed from a point nearer to the lens than the principal focus F, the angle of divergence being greater than at F, the lens is not sufficiently strong even to render them parallel, and they therefore continue to diverge after their passage through the lens, but not so much as before. In Fig. 17, the rays coming from P internal to the principal

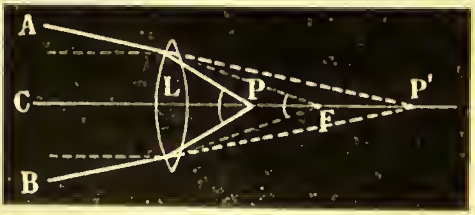

FIG. 17.—Virtual, or negative, conjugate foci of a convex lens.

focus, F, are rendered by their passage through the lens, L, less divergent than before; but, being divergent, they cannot come to a focus. To an observer at C, however, looking through the lens, the rays A and B would seem to come from a point P′, in the direction of their prolongation. P′ is the conjugate focus of P, but it is virtual as opposed to real, and is negative, or on the same side of the lens as P. If we consider the rays as travelling in the opposite direction, A and B with a convergence towards P′ will be focussed at P.

§19. **Foci of Concave Spherical Lenses.**—A concave lens renders parallel rays divergent. In Fig. 18, rays A and B, parallel to the principal axis P X, diverge as if they came from F, which is the principal focus of the lens. Rays from a near point will be rendered still more divergent, and will appear to proceed from a point still closer to the lens than the principal focus, F; but, in all cases, the conjugate focus will be apparent or virtual, and also negative, or on the same side of the lens as the point of light. Convergent rays are rendered parallel by a concave lens, if they converge towards the principal focus on the other side of the lens, and divergent if the point towards which they converge is further from the lens than the principal focus. They still remain convergent, but less so than before, if the point towards which they converge is closer to the lens than the principal focus.

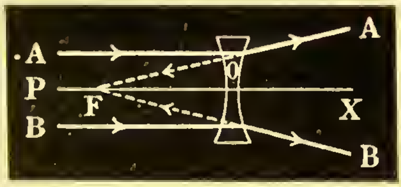

FIG. 18.—Principal focus of a concave lens.

§ 20. **Images formed by Spherical Lenses** consist of foci, each of which corresponds to a point in the object, and of which it is the conjugate focus. The image is real when the rays forming it actually meet and can be received on a screen; it is virtual when it does not in reality exist, but is formed by the imaginary backward prolongation of the rays, and can only be seen by looking through the lens.

§21. **Method of finding the Position and Size of an Image formed by a Spherical Lens.**—In order to find the position of the image of a point, say of O, Fig. 19, formed by a lens, first draw the secondary axis O I, which passes through the optical centre without deviation. The image will be formed on this axis at a point where the other rays proceeding from O intersect it. Two other rays (the paths of which are known) can be utilised; O A parallel to the principal axis will pass through the principal focus F_2, and the image of O will be at I, where A I meets O I, or I can be found by means of the ray O C, which passes through the principal focus, F_1, and therefore becomes parallel to the principal axis, taking the direction C I. In the following examples, the ray O A only will be used.

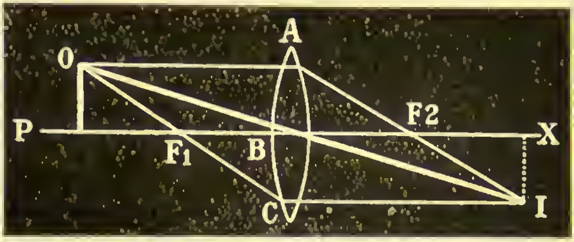

FIG. 19.—Image of a given point O formed by a convex lens.

§ 22. **Real Inverted Image formed by a Convex Lens.**—When an object is further from the lens than the principal focus, an inverted image is formed, as in Fig. 20, and the image is equal to the object A C, and at the same distance from the lens, if the object be at twice the focal distance from the lens. The image is larger if the object be

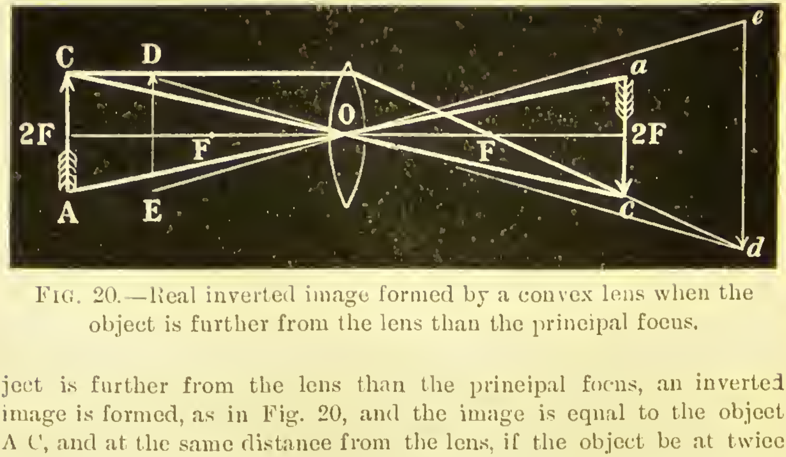

FIG. 20.—Real inverted image formed by a convex lens when the object is further from the lens than the principal focus.

closer than 2F ($c\,d$ is the image of D E), and smaller if it be further than 2F (D E is the image if $c\,d$ be the object). The closer the object is to the principal focus, the larger the image. It is in this way that the image is produced in the indirect method of ophthalmoscopy.

§23. **Virtual, Erect, and Magnified Image formed by a Convex Lens.**—When the object, C D (Fig. 21) is closer to the lens than the principal focus F_1, an erect, magnified virtual image, $c\,d$, can be seen on looking at the object through the lens. As the object approaches the lens, say to N P, the image, $n\,p$, becomes smaller; in other words, the virtual, like the real inverted image, increases in size the nearer the object is to F_1. It is in this way that a convex lens is used as a magnifying glass.

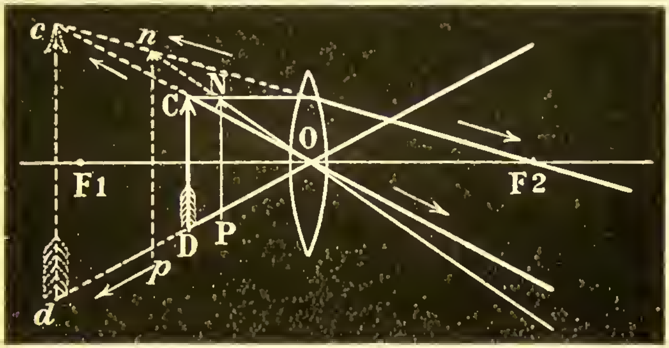

FIG. 21.—Virtual erect and magnified image formed by a convex lens, when the object is closer to the lens than the principal focus.

§ 24. **Images formed by Concave Lenses** are always erect, virtual, and diminished. The nearer the object is to the lens the larger the image. In Fig. 22 the point c or image of C is found at the intersection of S R (prolonged back to the principal focus, F) with the secondary axis C O N, and $d\,e$ is the image of D E.

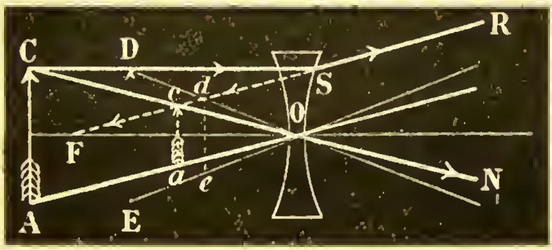

FIG. 22.—Virtual erect and diminished image formed by a concave lens.

§25. **Cylindrical Lenses.**—A lead pencil is a good example of a cylinder, the lead running down the centre being its axis. Any lines on the surface, parallel to the axis, are straight lines, whereas sections at right angles to the axis are always curved. If a slice were taken off the surface of the pencil, in the direction of its length or axis, and a round piece cut out of it, it would represent a convex cylindrical lens. A cast of the surface of the pencil would form a concave cylinder. Cylinders only act in the direction of their curvature; that is to say, at right angles to the axis. A cylinder has no effect in the direction of its axis. Rays entering in the plane of the axis are not refracted (Fig. 23, *a*), and rays entering in any plane parallel to the axis (Fig. 23, *b*) are merely bent towards the axis, but suffer no deviation in the direction of the axis (that is to say, vertically in Fig. 23). On the other hand rays in a plane at right angles to the axis, meeting the curved surface, are made to converge or diverge, according as the cylinder is convex or concave. (Horizontal plane in Figs. 23 and 24.) The focus of a cylinder therefore is a line parallel to the axis, and no image is formed.

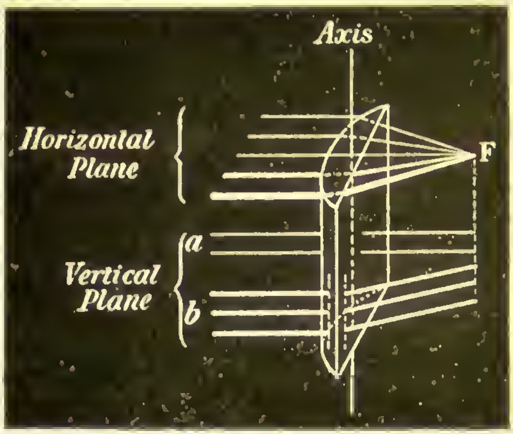

FIG. 23.—Refraction through a convex cylinder. F principal focus, which is really a line parallel to the axis.

The position of a cylinder placed before the eye, is indicated by the degree of inclination of its axis to the vertical or horizontal. The axis of the cylindrical lenses used in trial-cases is indicated by two slight scratches at the edge, or by two muffed portions parallel to the axis.

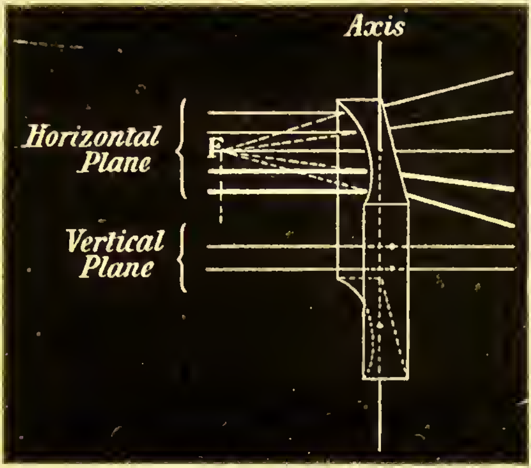

FIG. 24.—Refraction through a concave cylinder.

§26. **Numbering of Lenses.**—The lenses in trial-cases and in spectacles are numbered according to the metric system.

A lens of one metre focal length is adopted as the Dioptric Unit or unit of refractive power, and is called a Dioptre (1 D). The greater the strength or refractive power of a lens the higher will be its number, and the shorter will be its focal length (Fig. 15). Lenses of 2 D and 4 D are twice and four times as strong, respectively, as a lens of 1 D, and their focal lengths will be inversely, $\frac{1}{2}$ and $\frac{1}{4}$ of the focal length of the 1 D lens, that is to say $\frac{1m}{2}$ and $\frac{1m}{4}$, or expressed in centimetres (1 metre = 100 centimetres), $\frac{100}{2} = 50$ cm., and $\frac{100}{4} = 25$ cm.

If, therefore, it be required to ascertain the focal length of a given lens, 100 must be divided by the dioptric number of the lens, and the answer will give the focal length in centimetres. For example, the focal length of a lens of 5 D is $\frac{100}{5} = 20$ cm.

If the focal length of the lens be known, and it be desired to ascertain its dioptric number, we find it by dividing 100 cm. by the focal length. For example, if the focal length be 33 cm., then $\frac{100}{33} = 3$ D.

Lenses of less than 1 D have of course decimal fractions for their numbers—*e.g.*, 0·75, 0·5, and 0·25. The focal length of 0·5 D is $\frac{100}{0\cdot5} = 200$ cm. = 2 metres. Cylindrical lenses are numbered in the same way as sphericals. The strength of two lenses in contact is practically equal to the sum of their numbers, if of the same kind, and to the difference of their numbers if of the opposite kind—*e.g.*, + 4 D lens combined with − 1 D lens equals a + lens of 3 D.

§27. **Recognition of Spherical Lenses.**—If a spherical lens be moved before the eye, when looking at an object through it, the object will seem to move in the opposite direction in the case of a convex lens, and in the same direction, if the lens be concave. This is due to the

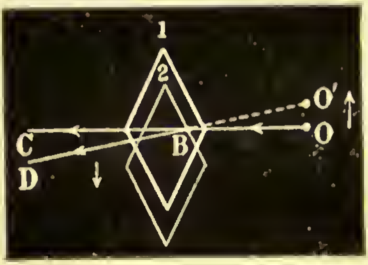

FIG. 25.—Apparent movement, in the opposite direction, produced by displacement of a convex lens. In position 2, O B is deviated towards the base of the prism to D, and O is seen at O′ (Chap. I. § 6)

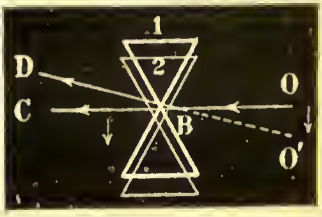

FIG. 26.—Apparent movement, in same direction, produced by displacement of a concave lens. In position 2 the prism is base up, O B is deviated to D, and O seems to be at O′.

prismatic action of the lenses (Figs. 25 and 26), and occurs equally in all diameters.

* §28. **Recognition of Cylindrical Lenses and of the Position of the Axis.**—Cylinders act in the manner described above for spherical lenses, but only in a direction at right angles to the axis. Further, if a cylinder be rotated while an object is viewed through it, it produces a distortion, when the axis is oblique with regard to the chief lines of the object. The effect is best seen if a rectangular object be selected, the angles of which are then no longer right or equal. This is noticeable even when the cylinder is combined with a spherical lens.

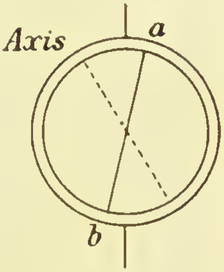

FIG. 27.

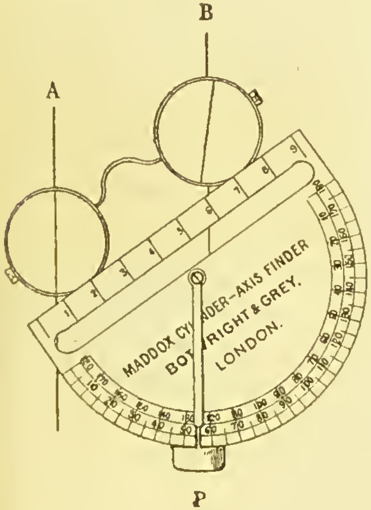

FIG. 28.

The simplest plan is to look at a vertical line through the glass, and if the axis of the cylinder be either vertical or horizontal, the portion of the line seen through the glass appears to be continuous with that outside it, whereas if the axis be oblique, as in Fig. 27, the portion seen through the lens becomes twisted into the position *a b*. Maddox's axis-finder, Fig. 28, is based on this principle. The spectacle frame is placed in a groove on the top of the instrument, and is held there, while both are tilted round until the line appears continuous as at A, Fig. 28; the pendulum, P, then indicates on the graduated arc the position of the axis, or the direction at right angles to it. The axis can also be found by the lens measurer (see below).

* §29. **To find the Number of a Lens** it is only necessary to neutralise it with a lens of the opposite kind taken from the trial-case. The two lenses are held in contact and moved together, while the apparent motion of an object as seen through them is noted, the lens which stops all movement giving the required number. Or it can be ascertained more rapidly by the Geneva lens measurer, Fig. 29. The three points *a*, *b*, *c*, the central one, *b*, of which is movable, are applied to the surface of the lens, and the corresponding number is indicated by the pointer on the dial. Both surfaces of the lens must of course be measured. The position of the axis of a cylinder is also easily found by this instrument. When the points are placed parallel to the axis the index stands at 0 (zero), showing that the surface is plane in that direction.

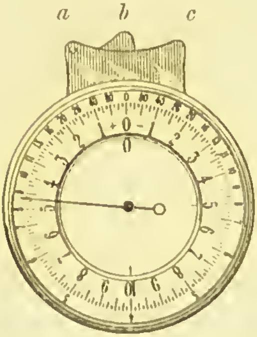

FIG. 29.—Lens measurer.

* §30. **To find the Optical Centre of a Lens** is often a matter of practical importance. It can be found in the same way as is the base-apex line of a prism (Fig. 7). When both the crossed lines seen through the lens are continuous with the portions outside the lens, the optical centre is opposite the point of intersection of the lines.

* §31. **Decentration of Lenses.**—Normally, the distance between the optical centres of the lenses in spectacles should be the same as that between the optic axes of the eyes of the patient, otherwise a prismatic effect would be produced. Sometimes, however, such an effect is desirable, and then it can be brought about by decentration of the lenses; which may be done in two ways, namely, by altering the distance

between the glasses by means of the frames, or by decentring the glass in its rim. The effect of the first method is shown in Fig. 30, from which figure, too, it is evident that, in order to produce the same effect, convex and concave lenses must be displaced in opposite directions.

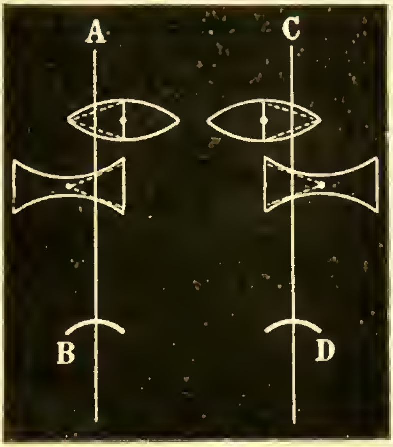

FIG. 30.—Prismatic effect of decentration of lenses. A B and C D represent the visual axes.

The second plan consists in cutting out the lens so that the optical centre is displaced with reference to the geometrical centre. By the geometrical centre we mean the central point of the piece of glass constituting the lens. In round glasses it is of course equally distant from all parts of the circumference, and in oval glasses it is at the centre of the horizontal diameter of the glass. In lenses, as commonly made, the optical centre coincides with the geometrical centre. Fig. 31 shows how a lens can be cut so that the optical centre will be decentred. A B is the lens as originally ground, and B C D is the portion which is cut out and fitted in the spectacle rim. If the whole of AB were used, the optical centre, O, would be the geometrical centre, but in the portion C B D the point G, midway between C D and B, would be the geometrical centre, while the optical centre, O, would be decentred. To obtain a prismatic effect of 1° a lens of 1 D requires to be decentred $1\frac{3}{4}$ cm. The stronger the lens the greater is the prismatic effect

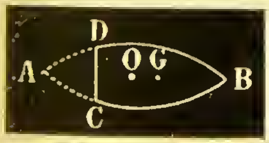

FIG. 31.—Decentration of a lens by cutting out a portion of it.

produced by a given amount of decentration, so that a lens of 2 D need only be decentred half the distance of a lens of 1 D, in order to produce the same prismatic effect. Tables have been made giving the prismatic effect of lenses of different strength corresponding to the extent of the decentration in millimetres.[1]

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[1] See Maddox's work *Ophthalmological Prisms.*

CHAPTER II.

OPTICAL STRUCTURE AND FUNCTIONAL EXAMINATION OF THE EYE.

PRELIMINARY NOTE ON THE CLINICAL EXAMINATION OF EYE PATIENTS.

IN general medicine and surgery, the importance of systematic clinical methods is well recognised. System is even more necessary in the clinical study of diseases of the eye, where the objects to be examined are often so minute that they may readily escape observation, and the symptoms depending on derangement of the functions of the organ are sometimes such, that the patient may himself be unaware of them.

Before examining the eye, a general observation of the patient should be made, whereby suggestive hints may be obtained for diagnosis. For example: the manner in which a patient enters a room may help to distinguish between an affection of the nervous apparatus of the eye and cataract, or his gait may suggest an affection associated with disease of the spinal cord. Again, a strumous appearance, enlarged glands, eczema, syphilitic eruptions, or the aspect due to hereditary syphilis afford information not to be disregarded.

There are many obvious local conditions, which are liable to escape the attention of a student who is, as so many are inclined to be, too precipitate in beginning a close inspection of the eyeball itself; for instance, the presence of slight strabismus, photophobia, or slight ptosis, or the sleepy appearance due to the heavy thickened lid in granular ophthalmia. These are mentioned merely to indicate the advantages which may be gained by taking a general view of the patient, and of his eyes, at a little distance, before proceeding to examine the latter more particularly.

The examination of the eye may be divided into three parts, which are usually taken in the following order: 1. Objective examination in daylight. 2. Subjective, or functional, examination. 3. Objective examination in the dark room. All these will be described in their appropriate places in the following pages, and it is only necessary here to mention some of their subdivisions. Under the first will come inspection (and palpation when possible) of the orbit, eyelids, lacrimal passages, conjunctiva, cornea, anterior chamber, iris (its colour and structure, and the mobility, shape, and size of the pupil), anterior layers of the lens in the pupillary area, and testing the intraocular tension. The second will include tests for acuteness of vision, field of vision, accommodation, orbital muscles, colour vision, and light-sense. Finally, in the dark room the anterior parts of the eye, including the lens, and sometimes the anterior portion of the vitreous humour, are first examined by reflected light with oblique illumination, and then with a strong + lens in the ophthalmoscope. The details of the fundus are then observed with the ophthalmoscope, and the refraction is estimated if necessary. One should never omit to compare the affected eye with its fellow, if only one eye be diseased.

It is not intended that all these methods of examination should be put into use, or considered even necessary, in every case; but they should be borne in mind, if nothing is to escape attention.

Optical Structure of the Eye.—The eye is a dark chamber lined by the uveal pigment, which prevents the rays of light from entering it, except through the transparent media and pupil. It possesses three refractive or dioptric[1] media, limited by three convex surfaces. The dioptric media are the aqueous humour, the substance of the crystalline lens, and the vitreous humour. The convex surfaces are the anterior surface of the cornea,[2] and the anterior and posterior surfaces of the crystalline lens.

By aid of this apparatus, which is called the dioptric system of the eye, distinct inverted images of external objects are formed on the retina.

The refracting surfaces, which are practically spherical, are centred on the *optic axis* ($O\ P$, Fig. 32), an imaginary line which, passing through the optical centre (N) of the eye, meets the retina at a point (P), the posterior principal focus, slightly to the inner side of the macula lutea (M).

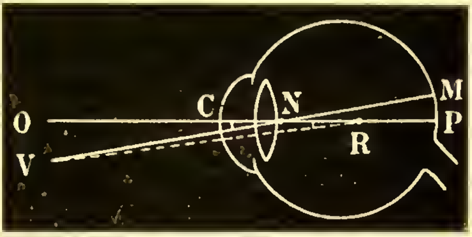

FIG. 32.—$O\ P$, Optic axis; $V\ M$, Visual line; $O\ R\ V$, angle γ; R, centre of rotation; N, nodal point; C, centre of cornea.

The optic axis of the eye is similar to the principal axis of a convex lens (see § 15, chap. i.). The optical centre N, which is called the *nodal point*, is situated just in front of the posterior surface of the lens, and rays passing through it are not deviated in their path, being in fact secondary axes. $V\ M$ is the *visual line*, which unites the object looked at with the macula lutea (M) and passes through the nodal point.

The *Line of Fixation* ($R\ V$) joins the centre of rotation (R) of the eye with the point of fixation. The angle $O\ R\ V$

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[1] The phenomena of refraction are sometimes referred to as Dioptrics, and those of reflection as Catoptrics.

[2] The posterior surface of the cornea may be neglected, since it is parallel to the anterior surface and the index of refraction of the cornea is the same as that of the aqueous humour.

formed at the centre of rotation, by the optic axis and the line of fixation, is called the angle γ.

The line of fixation and the visual line so nearly coincide that in practice we regard them as identical; and hence the angle γ is practically the same as $O\ N\ V$.

The angle κ is the angle between the fixation line and a perpendicular line through the cornea, opposite the centre of the pupil. In practice it is the angle κ which is measured. It is not equal to the angle γ, because the centre of the pupil is a little to the inner side of the centre of the cornea.

In order to measure the angle κ, the eye is placed at the perimeter as for an examination of its field of vision, that is to say, looking at the zero point. A candle flame is then moved along the arc of the perimeter, until the corneal image of the light appears to the observer (whose eye is in a line with candle and image) to be in the centre of the pupil. The position of the flame at the perimeter then gives the angle κ. The average size of the angle κ is 5°.

REFRACTION.

By the Refraction of the Eye is meant, in a general sense, the faculty it has *when at rest* (*i.e.*, without an effort of accommodation) of altering the direction of rays of light which pass into it, making parallel rays convergent, and divergent rays less divergent. But, as usually understood, it means the relation which the position of the retina bears to the principal focus of the dioptric system.

In Normal Refraction, or Emmetropia (*ἔμμετρον*, *the standard*; *ὤψ*, *the eye*), as it is termed, the retina lies at the posterior principal focus (fig. 33), and therefore parallel rays are brought to a focus on the layer of rods and cones of the retina, and form on it a distinct inverted image of the point or object from which they come. The emmetropic eye, in a state of rest, is thus adapted for distant objects, and its far point (punctum remotum) is at infinity. Conversely, if the retina be illuminated, the rays proceeding from any point on it will emerge from the eye parallel. In the normal eye the posterior focal length of the dioptric system is 23 mm., and the average length of the eyeball including the sclerotic is 24 mm.

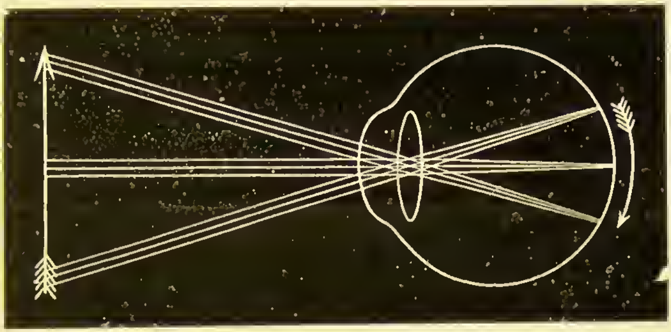

FIG. 33.

ACCOMMODATION.

The eye can see near objects distinctly as well as distant objects, although the rays from any given point (*a*, Fig. 34) of a near object reach the eye with a divergence so considerable, that they could not be brought to a focus on the retina by the unaided refraction, but would converge towards a point (their conjugate focus *a′*) behind the retina, and would not form a distinct image on the latter, but merely a blurred

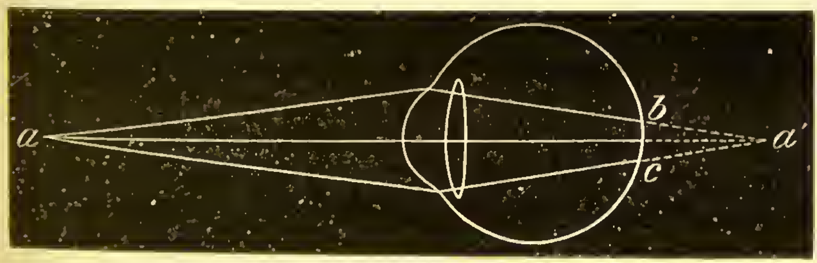

FIG. 34.

image or circle of diffusion (at *b c*). It is obvious, therefore, that an increase of refracting power in the eye is necessary, in order that near objects may be distinctly seen. It is this increase in the refracting power for the purpose of near vision which is called Accommodation.

The Mechanism of Accommodation is as follows:—The ciliary muscle (*m*, Fig. 35) contracts, thus drawing forward the chorioid and the ciliary processes, and relaxing the zonula of Zinn (*z*), which is attached to the latter. The lens (*l*), which was flattened by the tension of the zonula, is now free to assume a more spherical shape, in response to its own elasticity. The posterior surface of the lens scarcely alters in shape, being fixed in the patellary fossa; but the anterior surface becomes more convex, thus increasing its refracting power. Associated with the act of accommodation is a contraction of the pupil. The accompanying figure (Fig. 35) represents the changes which take place in accommodation, the dotted lines indicating the latter state.

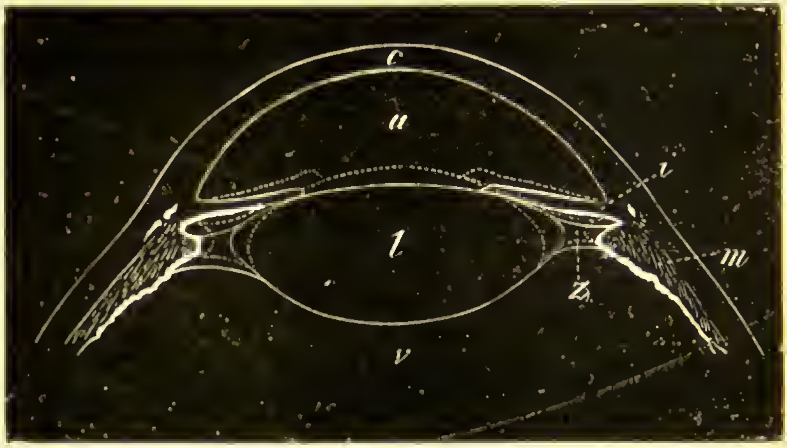

FIG. 35.—*c*, cornea; *a*, anterior chamber; *l*, lens; *v*, vitreous humour; *i*, iris; *z*, zonula of Zinn; *m*, ciliary muscle.

Tscherning has shown that the increased curvature of the anterior surface of the lens occurs mainly in the centre of that surface—in other words, that in accommodation the anterior surface becomes somewhat conical, and not merely more spherical. He holds that this is due to a tightening, and not to a relaxation of the zonula. This theory has been vigorously combated by other observers, and its true value remains to be determined.

Accommodation is always associated with contraction of the pupil and convergence of the optic axes.

The Far Point and the Near Point.—It is possible for the eye, by changing the accommodation, to see objects accurately at every distance from its Far Point—*i.e.*, its most distant point of distinct vision (Punctum Remotum,—R.), up to a point only a few centimetres from the eye, called the Near Point (Punctum Proximum,—P.). We can find the latter by directing the patient to look at a page printed in small type, and by bringing it slowly closer and closer to his eye, until a point is reached where he cannot distinguish the words and letters, which become blurred. A point very slightly more removed from the eye than this, where he can read distinctly, is the near point. Between the near point and the eye vision is indistinct, because no effort of the ciliary muscle can produce the amount of convexity of the lens required for so short a distance.

* **The Amplitude and Range of Accommodation.**—This is the amount of accommodative effort of which the eye is capable—*i.e.*, the effort it makes in order to adapt itself from its Far Point (R.) up to its Near Point (P.). The amplitude of accommodation (a), therefore, is equal to the difference between the refracting power of the eye when at rest (r), and when its accommodation is exerted to the utmost (p), as expressed by the formula $a = p - r$. It may be represented by that convex lens placed close in front of the eye, which would take the place of the increased convexity of the lens, or, in other words, which would give to rays coming from the nearest point of distinct vision a direction as if they

came from the far point. The number of this lens expresses the amplitude of accommodation in a given eye.

For example: if, in an emmetropic eye (*E*, Fig. 36) the near point be situated at 20 cm., then a convex lens (*L*) of 20 cm. focal length placed close to the eye (between that point and the eye) would give to rays coming from the near point a direction as though they came from a distant object (*i.e.*, would make them parallel), and this normally refracting eye would then be enabled by aid of its refraction alone to bring these rays to a focus on the retina. Making use of the above equation, we find in this case—since a focal length of 20 cm. represents a lens of 5 D—that $a = 5 - r$, but R being situated at infinity (designated by the sign ∞), $r = \frac{1}{R} = \frac{1}{\infty} = 0$; therefore $a = 5 - 0 = 5$ D.[1]

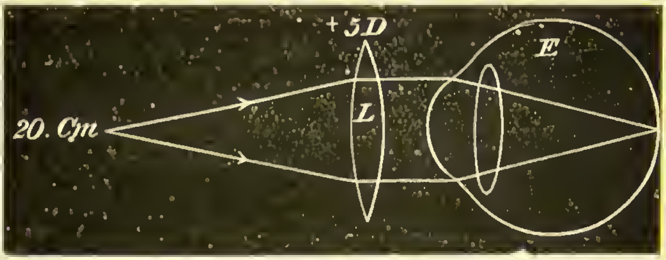

FIG. 36.

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[1] It must be observed that R represents the *distance* of the Far Point from the eye, while r represents the *refractive power* which is added to the eye by accommodation, or by a lens, in order to adapt it for the distance R. Hence it is evident that $r = \frac{1}{R}$, because the strength, or refractive power, of a lens is inversely as its focal length—*e.g.*, a lens of the strength of 4 D will have a focal length of $\frac{1}{4}$ that of a lens of 1 D—*i.e.*, $\frac{1 \text{ m.}}{4} = \frac{100 \text{ cm.}}{4} = 0{\cdot}25$ cm. (see § 26 p. 15). Similarly, $p = \frac{1}{P}$ and $a = \frac{1}{A}$; P representing the *distance* of the Near Point, and A the focal length of the lens a which represents the Amplitude of Accommodation.

The amplitude of accommodation (*i.e.*, the number of the lens which would represent it) is the same in every kind of refraction, according to the age of the individual, but in emmetropia alone is $a=p$ as above, because in it alone is $r=0$.

It is evident that, as the refractive power of the eye is increased during accommodation, the eye is rendered temporarily myopic as regards parallel rays (Fig. 37).

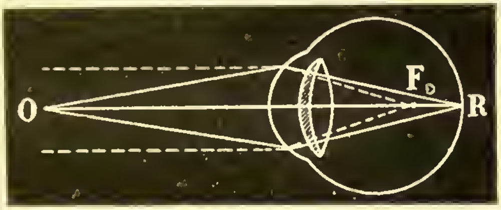

Fig. 37.—Eye accommodated for *O* which forms a distinct image on the retina, *R*. Parallel rays now unite in front of the retina at a shorter distance, *F*.

Under the head of "Anomalies of Accommodation," chap. iii., will be found Donders' diagram representing the amplitude of accommodation at different ages.

The Range of Accommodation is the distance between the far point, R, and the near point, P. As will be seen later on, it is not always the same for a given amplitude.

Connection between Accommodation and Convergence (Relative Accommodation).—By convergence we mean the inward rotation of the eyes which is necessary in looking at a near object, in order to obtain single vision with both eyes. With each degree of convergence of the visual lines a certain effort of accommodation is associated. Thus, if the object be situated 2 metres from the eye, the visual lines converge to that point, and a certain effort of accommodation (0·5 D.) is made. But this connection between accommodation and convergence is somewhat elastic, for the accommodative effort may be increased or decreased, while the object is kept distinctly in view, and the same convergence maintained. That it may be increased is shown by the experiment of placing a weak concave glass before the eye, when it will be found that the object is still distinctly seen; and if a weak convex glass be then held before the eye the object will also be clearly seen, showing that the accommodative effort may be lessened without affecting vision or convergence. This amplitude of accommodation for a given point of convergence of the visual lines, found by the strongest concave and strongest convex glasses with which the object can still be distinctly seen, is called the Relative Amplitude of Accommodation. That part of it which is already in use, and is represented by the convex lens, is termed the negative part; while the positive part is represented by the concave lens, and has not been brought into play. For sustained accommodation at any distance, it is necessary that the positive part of the relative amplitude of accommodation be considerable in amount.

Moreover, the convergence may be altered, while the same effort of accommodation is maintained, as is shown by the experiment of placing a weak prism with its base inwards before one eye. In order that the object may then be seen singly, it will be necessary for the eye before which the prism is placed to rotate somewhat outwards; and it will be found that the individual can do this, while at the same time he sees the object with the same distinctness, showing that the same effort of accommodation has been maintained, although the angle of convergence of the visual axis is less than before.

CONVERGENCE.

* **Range and Amplitude of Convergence.**—The nearest point for which the eye can converge and still see single is the near point of convergence. The far point of convergence is the point at which the visual lines meet when the eyes are at rest; as the position of rest is one of slight divergence, this imaginary point usually lies behind the head, and the deviation from parallelism to this degree of divergence is known as negative convergence. The amplitude of

convergence is the sum of the positive and negative convergence. The Range of Convergence is the distance between the far and near points of convergence.

The near point of convergence is found by bringing an object, such as a fine line, up to the eyes in the middle line, until it begins to be seen double. The far point of convergence or rather the negative convergence, can be measured by prisms placed base inwards while the patient looks at a distant object. In some cases the eyes are parallel or slightly convergent when at rest, and then convergence is altogether positive.

THE UNIT OF CONVERGENCE. THE METRE ANGLE.

If the visual line (*E* 1, Fig. 38) of an eye (*E*) be brought to bear on a point (1, Fig. 38) 1 metre distant from it in the median line (*M* 1), the angle of convergence (*E* 1 *M*) which the visual line thus makes with the median line is called the Metre Angle. It expresses the degree of convergence necessary for binocular vision at that distance, and is employed as the unit for expressing other degrees of convergence. If, for example, an object be situated $\frac{1}{2}$ a metre ($\frac{1}{2}$, Fig. 38) from the eye, the angle of convergence (*E* $\frac{1}{2}$ *M*) must be practically twice as large as at 1 metre: C. (Convergence) = 2 metre angles. If the object be only $\frac{1}{3}$ of a metre distant, 3 metre angles are required: C. = 3 metre angles. If the object be situated 2 metres from the eye, the angle of convergence will be only one-half as great as at 1 metre, and here C. = $\frac{1}{2}$ metre angle; while if the eye be directed towards a distant object (*D*) there will be no angle of convergence, and if the visual lines be divergent the metre angle will be negative.

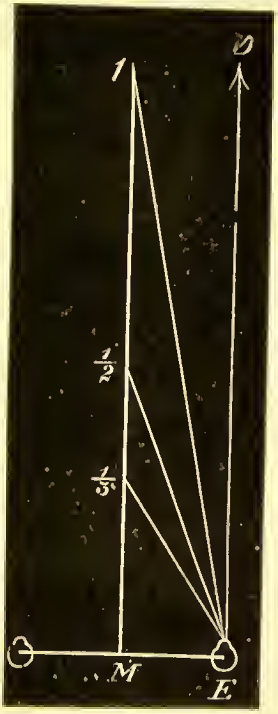

FIG. 38.

Now the average normal emmetropic eye requires for each distance of binocular vision as many metre angles of convergence as it requires dioptries of accommodation. For a distance of 1 metre an effort of accommodation of 1 dioptre is required, and also 1 metre angle of convergence; at $\frac{1}{2}$ metre from the eye 2 D of accommodation is required and 2 metre angles; at $\frac{1}{3}$ metre from the eye 3 D of accommodation and 3 metre angles, and so on; while for distant objects neither convergence nor accommodation is required. The positive portion of the average normal convergence is about 10 metre angles and the negative 1 m.a.

THE SENSE OF SIGHT.

The Sense of Sight consists of three Visual Perceptions or Sub-Senses—namely, the Light-Sense, the Colour-Sense, and the Form-Sense.

* **The Light-Sense** is the power the retina, or the visual centre, has of perceiving gradations in the intensity of illumination. A convenient clinical method of testing the light-sense is the photometer invented by Messrs. Izard and Chibret. On looking through this instrument towards the sky two equally bright discs are seen. By a simple mechanism one of the discs can be made darker. If the eye does not perceive the difference in illumination between the two discs within 5° its light-sense is abnormal, or we may say its L.D. (Light Difference) is too high. Again, if one disc be made quite dark, and be then gradually lighted, the patient is required to indicate the smallest degree of light, or L.M. (Light Minimum), by which he can observe the disc issuing from the darkness. This should not be more than 1° or 2°.

Another good method is that of Bjerrum, in which the light-sense is tested by grey letters on a white ground, the letters being constructed on the same principle as Snellen's Test Types.

A useful and ready clinical method consists in gradually diminishing the illumination of the test-types and comparing the acuteness of vision of the patient with that of the surgeon, provided the latter have a normal light-sense. The L.D. is most affected in diseases of the optic nerve, and the L.M. in chorioido-retinal affections.

* **The Colour-Sense** is the power the eye has of distinguishing light of different wave-lengths. According to the Young-Helmholtz theory, the retina possesses three sets of colour-perceiving elements, those for Red, Green, and Blue or Violet. These are termed primary colours, all other colours being compounds of them.

According to Hering's theory, the colour-sense and the light-sense depend upon chemical changes in the retina or in the visual substances contained in the retina. He suggests the existence of three different visual substances, the white-black, the red-green, and the blue-yellow, by the using up or Dissimilation, and restoration or Assimilation, of which substances the sensations of light and colour are produced. In the case of the white-black substance the sensation of white, or of light, corresponds to the process of dissimilation; while the sensation of black, or of darkness, corresponds to the process of assimilation. For the red-green and blue-yellow substances it cannot be said which colour-sensation implies assimilation and which dissimilation. The members of the black-white pair can mingle with each other and with those of the other two pairs; but the respective members of the two-colour pairs (being contrast colours), *e.g.*, blue and yellow, cannot unite with each other.

In testing the colour-sense the spectral colours are the best for exact experiments, but the difficulty of producing them at every moment, and of combining them, renders them of little clinical use.

The clinical method commonly employed for testing the colour-sense is that of Professor Holmgren, of Upsala, which is based upon the Young-Helmholtz theory. The test-objects used are coloured wools, of which a large number of skeins of every hue are thrown together.

Test I. (*vide* card on inside of end cover) consists in presenting to the individual, in good diffused daylight, a pale but pure green sample, and requiring him to select out of the bundle of wools of all colours before him all of those samples which seem to him to correspond to the test sample. If this be done correctly it is unnecessary to proceed further: the individual has normal colour-sense. Amongst the skeins, however, there are some which are termed colours of confusion (greys, buffs, straw-colour, etc.); and if he select one, or several, of these he is colour-blind.

If, now, it be desired to ascertain the kind and degree of his defect we proceed to Test II.*a*. A pink (mixture of blue and red) skein is given to be matched. If this be correctly done, the person is termed incompletely colour-blind; but if blue and violet, or one of them, be selected, he is red-blind (sees only the blue in the mixture of blue and red); if he select green or grey, or one of them, he is green-blind.

In order to corroborate the investigation Test II.*b* may be employed. A vivid red skein is given. The red-blind chooses, besides red, green and brown shades darker than the red; while the green-blind chooses green and brown shades lighter than the red. But it is now very generally recognised, that red-blindness and green-blindness invariably go together. In violet (or blue) blindness purple, red, and orange will be confused in Test II.*a*; but this is an extremely rare variety of colour-blindness. Total colour-blindness will be recognised by a confusion of all shades having the same intensity of light, and is also rare. It is impossible by this test for any colour-blind person to escape detection, except in the case of a small central colour scotoma.

The individual tested should not be allowed to name the colours, but merely to match them, as above described. The reason for this is twofold. First, because, although the congenitally colour-blind person is usually unaware of his defect, yet experience has taught him which of his sensations are called blue, red, etc., by other people; and hence he can often apply the right names to colours which he really does not see as such. He is assisted in this by whatever of colour-sight is left to him and by the brightness and saturation of the different colours, but is liable to frequent mistakes. Again, when the colour-blind person does happen to know of his defect he is often desirous of concealing it, either because he is ashamed of it or from interested motives.[1]

Edridge Green's theory is that light falling upon the retina liberates the visual purple from the rods, and a photograph is formed. The decomposition of the visual purple by light chemically stimulates the ends of the cones, and a visual impulse is set up, which is conveyed through the optic nerve fibres to the brain. He assumes that the visual impulses caused by the different rays of light differ in character, just as the rays of light differ in wave length. Then in the impulse itself we have the physiological basis of light, and in the quality of the impulse the physiological basis of colour. He also assumes that the quality of the impulse is perceived by a special perceptive centre within the power of perceiving differences possessed by that centre or portions of that centre.

Edridge Green divides the colour-blind into two distinct classes, independent of each other, but which may be associated. The first class includes those who are not able to see certain rays of the spectrum; their spectrum is shortened at one or both ends. If an individual have shortening of the red end of the spectrum, he will not be able to see a red light at a distance, though he might be able to pick out all the green wools in Holmgren's Test I. A man of this kind, when shown the red light of Edridge Green's Lantern Test, declares that there is no light visible, thus at once demonstrating his incapacity. The second class of the colour-blind make mistakes, not because they cannot perceive a certain colour, but because they are not able to recognise the difference between the colours, which is evident to normal-sighted persons. Normal-sighted persons see six definite colours (points of difference) in the spectrum. The second class of the colour-blind see five, four, three, two, or one colour, according to the degree of the defect; and they confuse the colours of the normal-sighted, which are included in one of their own. If the normal-sighted be designated hexachromic, those who see five colours may be called pentachromic; those who see four, tetrachromic; those who see three, trichromic; those who see two, dichromic; and the totally colour-blind, monochromic.

Edridge Green uses two tests—a Classification Test and a Lantern

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[1] More detailed information and Holmgren's test will be found in Appendix I.

Test. The Classification Test consists of a number of coloured wools, silks, cards, and glasses, with four test-colours—orange, violet, blue-green, and red. The examinee is asked to name the test-colours, and then to pick out from the pile all of similar colour. The Lantern Test consists of a lantern and coloured glasses, which can be shown alone, or combined or modified by neutral glasses. The examinee is asked to name the colour of the light shown. Edridge Green is of opinion that the use of colour names is absolutely necessary, or normal-sighted persons will be rejected, through paying attention to shade rather than to colour. It does not matter what name is applied to a colour; but ground for rejection is afforded when the examinee calls two of the main colours of the normal-sighted, as, for instance, red and green, by the same name.

A certain proportion of people (3·5 per cent. of men and less than 1 per cent. of women) are congenitally colour-blind in greater or less degree, without any diminution in the other visual functions.

Acquired colour-blindness is found in toxic amblyopia, in atrophy of the optic nerve, and under some other conditions.

The Form-Sense (Acuteness of Vision) is the faculty the eye possesses of perceiving the shape or form of objects, and in clinical ophthalmology the testing of this function is an important and ever-recurring duty.

In order that an individual may have good use of his eyes it is necessary, not only that the optic nerve, retina chorioid, and refracting media be healthy, but also that th refraction and accommodation be normal. When applied t by a patient on account of imperfect sight it is our firs duty, as a rule, to ascertain accurately the condition o refraction and accommodation of his eyes. Should these b abnormal, and it be found that by aid of the correctin glasses perfect vision is obtained, it may in general be co cluded that the eye is organically sound, and that th patient's complaints are due to the defect in accommodatio or refraction. If the glasses do not restore perfect vision, w must then, by the ophthalmoscope and other methods, deci the nature of the defect.

By Acuteness of Vision (V.) is meant the power which an eye, or rather its macula lutea, has of distinguishing form, any anomaly of its refraction, if such exist, having been first corrected, *i.e.*, while the patient wears the correcting glasses.

Now, in order to measure the acuteness of vision we must have a normal standard for comparison—*i.e.*, we must find what is the size of the smallest retinal image whose form can be distinguished. We cannot, of course, measure this image on the retina directly; but, as its size is proportional to the visual angle—the angle which the object subtends at the eye—it is sufficient to determine the smallest visual angle under which the form of an object can be distinguished. It has been found, experimentally, that the average size of this angle is 5′ (Fig. 39).

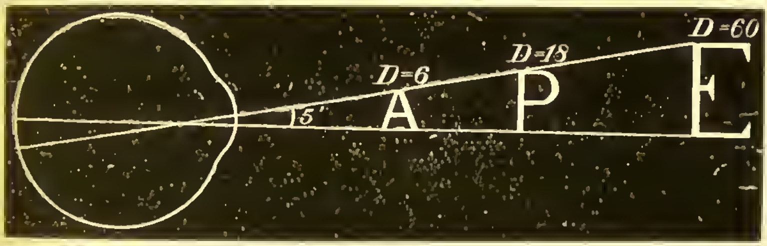


FIG. 39.

In order practically to ascertain the degree of acuteness of vision, we place our patient with his back to the light, while facing him at a distance of 6 metres, and in good light, are placed Snellen's Test-Types for distance. These types are so designed that, at the distance at which they should be seen, they each subtend an angle of 5′ at the eye. The largest type should be seen at 60 metres (Fig. 39) by the normal eye, and the types range from this down to a size visible not farther off than 6 metres. If V = Acuteness of Vision, d = the distance from the eye to be tested to the test-types, and D = the distance at which the type should be distinguishable, then $V = \frac{d}{D}$. For example: if $d = 6$ metres (a distance which most rooms can command), and if the eye see type D = 6, then V = $\frac{6}{6}$ = 1, or normal V.; but if at 6 metres the eye see only D = 60, which should be seen at 60 metres, then V = $\frac{6}{60}$, in short V = 6 divided by the number of the type read.

A series of types resembling the letter E, in various positions, is also used for testing illiterates. The types of Jaeger for near vision are sometimes used for testing the acuteness of V.

Should the patient's sight be so bad that he is unable to read any of the letters, it may be tested by finding at what distance he can count the surgeon's fingers; and if he cannot even do that, then his power of perception of light (his P.L.) should be tested. This is done by means of a lamp in a dark room, the eye being alternately covered and uncovered, and the patient being required to say when it is "light" and when "dark." If tho flame be gradually lowered the smallest degree of illumination perceptible will be ascertained.

The eyes must be examined separately, that one not under examination being excluded from vision by being shaded with the patient's own hand or other suitable screen; but it must not be at all pressed on, as any pressure would dim its vision when its turn for examination may come.

With the advance of age tho acuteness of vision undergoes a slight but steady reduction, owing to certain senile changes in the eye.

THE FIELD OF VISION.

By the Field of Vision (F.V.) is meant the space within which, when one eye is closed, objects can be seen by its fellow, the gaze of the latter being fixed the while on some one object or point. Thus if, standing on a hill, we fix the gaze of one eye on some object on the plain below, the field of vision includes not only that object, but many others also for miles around it.

The fixation object is seen by central or direct vision, its image being formed on the macula lutea; the other objects in the field of vision correspond with as many different points in the more peripheral parts of the retina, and are seen by eccentric, or indirect, vision. Eccentric vision is of great importance for the guiding of ourselves and avoiding obstacles in our way. Its use may be realised by the experiment of looking through a long small-bore cylinder (*e.g.*, a roll of music) with one eye, thus cutting off its eccentric field, while the other eye is closed.

The Dimensions of the Field of Vision may be measured for clinical purposes by means of an instrument called the perimeter. This is a semicircular metal band, which revolves upon its middle point, being in this way capable of describing a hemisphere in space. The arc is divided into degrees marked on it, from 0° placed at its middle point, to 90° at either extremity. At the centre of the hemisphere is situated the eye under examination, while the fixation point is placed exactly opposite, in the centre of the semicircle, at 0°. A small bit of white paper 5 mm. square, the test object, is slowly moved along the inner surface of the arc from the periphery towards the centre, until it comes into view, and this point is observed in various meridians. The horizontal, vertical, and two intermediate meridians, at the least, should be examined by placing the arc of the perimeter in the corresponding planes.

The boundary of the field may be noted on a diagram or chart (Fig. 40), which represents the projection of a sphere on a plane surface. The radii represent different meridians, which may be determined by a dial with pointer on the back of the perimeter, while the concentric circles correspond with the degrees marked on the arc. A pencil mark is placed on the chart at the spot corresponding to that on the perimeter at which the test object comes into view, and when the different meridians have been examined these marks are united by a continuous line, which then represents the outer boundary of the F.V.

The normal F.V. is not circular, but extends outwards about 95°, upwards about 53°, inwards about 47°, and downwards about 65°, as represented by the strong curve in Fig. 40. The limitation upwards and inwards is partly due to the projection of the supra-orbital margin and the bridge of the nose, but also to the fact that the outer and lower parts of the retina are less practised in seeing than are the upper and inner parts, and their functions consequently less developed,

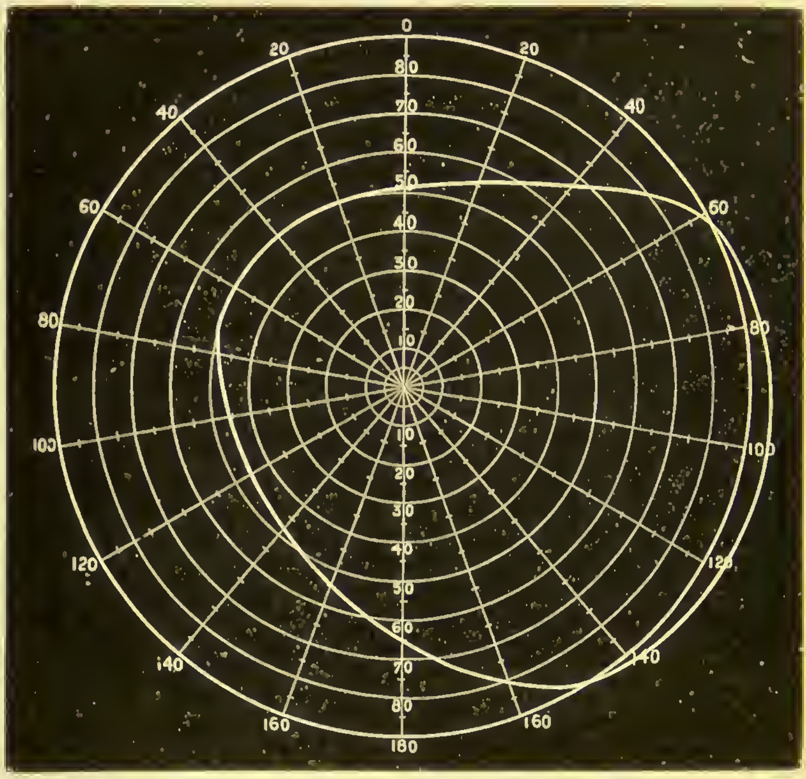


FIG. 40.—Chart of F.V. of Right Eye.

The acuteness of vision diminishes progressively towards the periphery of the field, two points of a certain size close together being distinguishable from each other only a short distance from the fixation point, while the farther towards the periphery the larger must be the test objects.

Fig. 41 serves to illustrate the projection of the field of vision on the semicircle of the perimeter to its extreme temporal (95°) and its extreme nasal (47°) boundaries, as well as the portion of the retina (*a* to *b*) which corresponds to this extent of field; and it shows that the sensitive portion of the retina, or rather perhaps the portion of the retina which is most used, extends farther forward on the nasal than on the temporal side. The diagram also explains the remarkable fact that the field extends in the temporal direction more than 90°.

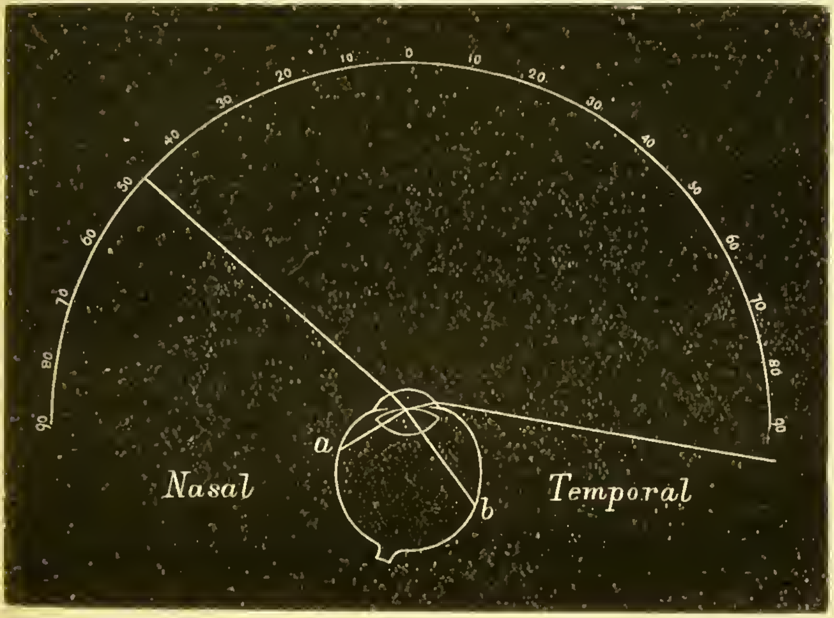


FIG. 41.

It must be remembered, too, that the fields of vision overlap, (Fig. 42) as the two visual axes meet at the fixation point.

The Blind Spot of Mariotte is a small blind island or scotoma in the F.V., situated about 15° to the outer side of the point of fixation and just below the horizontal meridian. It is shown as a white spot in Fig. 43. It is due to the optic papilla (optic disc), for at that place the outer layers of the retina are wanting, and hence it possesses no power of perception. There are also, occasionally, minute blind spots in the field, due to large retinal vessels, which interfere with the formation of the image upon the layer of rods and cones.

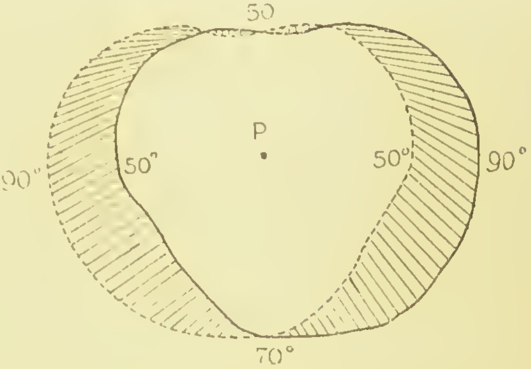


FIG. 12.—Binocular Field of Vision. The white area is common to both eyes, P. being the fixation point. The shaded portion on the right belongs to the right eye alone, while that on the left belongs to the left eye alone.

The field of vision may also be tested by means of a blackboard; although peripheral contractions cannot be discovered in this way, it is very useful for detecting central defects (see Toxic Amblyopia).

The presence of a gross alteration in the field may be roughly ascertained if the observer face the patient, who has his back to the light, and use his own hand as a test object. The eye of the observer which is opposite the patient's eye serves as a control, as its field can be tested at the same time as that of the patient's eye.

Pathological Defects in the Field of Vision.—These may consist in Contractions or in Insular Defects. Contraction of the field takes place either concentrically, that is to say to an equal extent all around the periphery, or irregularly, for instance on the nasal or temporal sides alone.

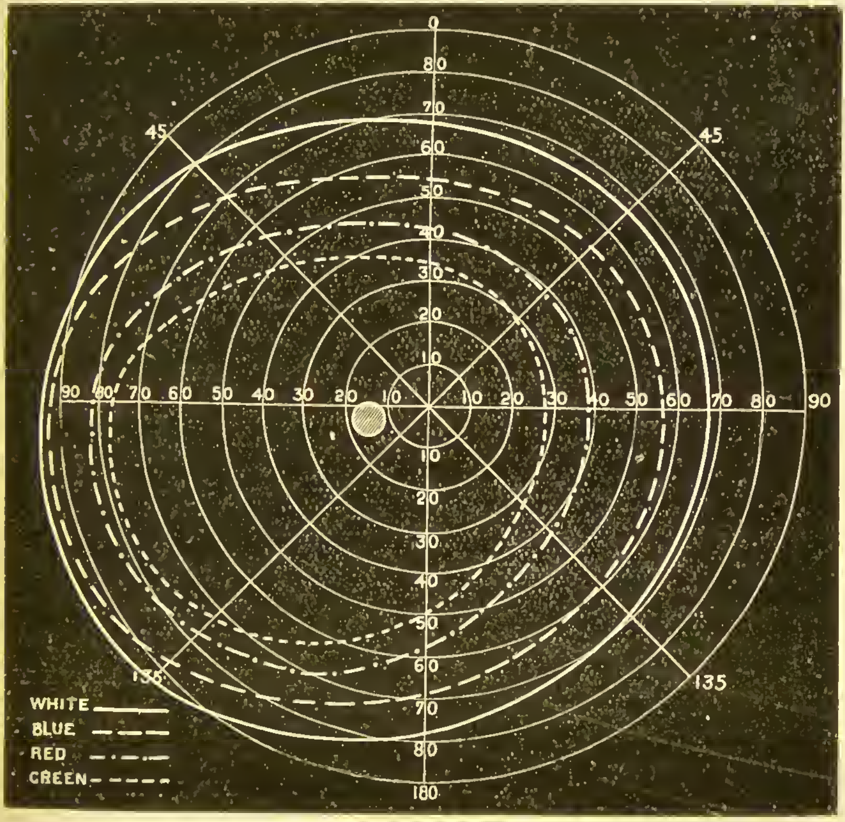


FIG. 43 (*Landolt*).—Chart of F.V. of Left Eye.

Occasionally sector-like defects occur. Loss of one half the field is known as Hemianopsia. A defective island in the field of vision is called a Scotoma and it may be central—that is, involving the fixation point—eccentric, or peripheral. A defect in the field is Positive if it be visible to the patient as a dark area, Negative if it be invisible. If the blindness be complete, the defect is said to be Absolute; but if the acuteness of vision be merely diminished, it is said to be Relative. A relative defect may exist for colours only. In all eyes the blind spot is a negative and absolute scotoma in the field of vision.

The Perception of Colours in the Periphery of the Field can be examined with the perimeter, by means of bits of coloured paper 5 mm. square. It has been in this way ascertained that the boundaries of the power of eccentric perception for the different colours do not seem to correspond with the boundary for white light, nor do the boundaries of the different colours seem to coincide. Examining from the periphery towards the centre by ordinary daylight, blue is the colour which can be distinguished as such most eccentrically, its field extending nearly as far as the general F.V.; then come yellow, orange, red, and, with the most limited field, green. Blue, red, and green being the most important, their fields are noted in Fig. 43. Although the respective colours are distinguishable within the limits indicated, they are by no means so brilliant in hue as when seen by direct vision. It has, however, been demonstrated that every colour is recognisable up to the outer limit of the F.V., if the coloured object be of sufficient surface and be sufficiently illuminated; so that there is, in fact, no absolute colour-blindness in the peripheral parts of the retina, but merely a diminished sensitiveness to coloured light.

The Perception of Form in the Periphery of the Field is very defective, and its examination is not of much practical importance; but this portion of the field is very sensitive to the movement of objects.

CHAPTER III.

ABNORMAL REFRACTION AND ACCOMMODATION.

Ametropia.—It has been explained (p. 24) that, in Emmetropia or Normal Refraction, the retina is at the principal focus of the dioptric system. When the retina does not coincide with the principal focus, parallel rays no longer meet on it, if the accommodation be at rest ; this condition is called Ametropia (*a, priv. ; μέτρον, standard ;* ὤψ), or an error of refraction. There are three varieties of Ametropia. 1. Myopia (*μύειν, to close ;* ὤψ), or Short-sight ; in which the principal focus lies in front of the retina. 2. Hypermetropia (*ὕπερ, over ; μέτρον, standard ;* ὤψ), in which the principal focus lies behind the retina. 3. Astigmatism (*a, priv. ; στίγμα, a point*), in which the refraction of the eye in its different meridians is different.

MYOPIA, OR SHORT-SIGHT.

Definition and Optical Causes of Myopia.—Myopia is an error of refraction in which the retina lies behind the principal focus of the dioptric system, and in which therefore parallel rays of light (*a b*, Fig. 44) are brought to a focus, not on the retina, but in front of it (at *f*), and form on it circles of diffusion (*c d*).

Compared with emmetropia, therefore, the refraction of the myopic eye is increased. This may be due to shortening of the focal length by an absolute increase in the refractive power of the eye, brought about by increase of the curvature of the cornea, as in conical cornea, or of the crystalline lens, as in spasm of accommodation (Curvature M.), or by alteration in the refractive index of the crystalline lens (Index M.), as in some cases of commencing cataract, but in these the myopia is only of secondary importance.

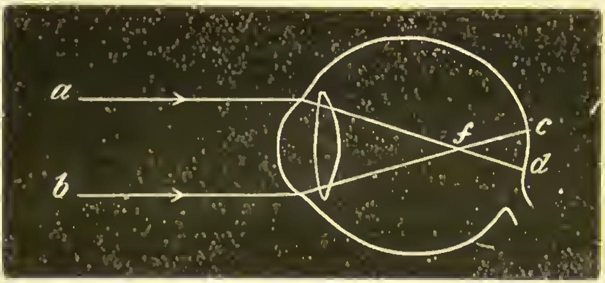


FIG. 44.

The most common cause of myopia is an elongation of the antero-posterior axis of the eyeball (Axial M.), and in this case the increase of the refraction is therefore only relative.

Far Point (Punctum Remotum, R.), of the Myopic Eye.—The myopic eye cannot see distant objects (at six metres or more) distinctly, because of the circles of diffusion (*c d*, Fig. 44), but if the object be brought closer, its conjugate focus (§16, Chap. I.) will lie further back than *f*, Fig. 44, and when the object reaches a certain point nearer to the eye, say R,

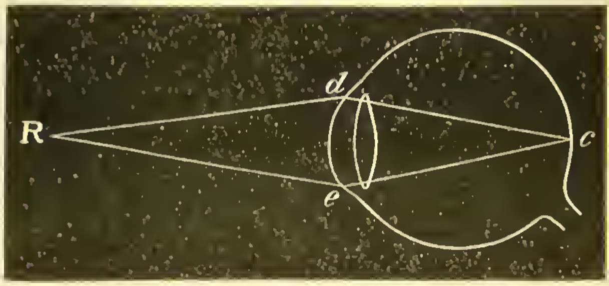


FIG. 45.—Far point of a myopic eye.

Fig. 45, its conjugate focus will meet the retina (at c) and it will be distinctly seen. This point—which is the furthest point of distinct vision—is the Far Point or Punctum Remotum (R.). The myopic eye is therefore adapted for seeing near objects. Conversely rays emerging from c will unite at R, which is the conjugate focus of the retina. It will be observed that, in myopia, R is real and can actually be measured, that it lies in front of the eye and is a positive quantity. As the *position* of R in front of the eye determines the *nature* of the error of refraction, so the *degree* of error depends on the *distance* of R from the eye; the longer the eyeball the closer is R, and the greater is the error of refraction. In other words the error of refraction (r) is the inverse of the distance of the Far Point (R), $r = \frac{1}{R}$, and conversely of course $R = \frac{1}{r}$. These are general equations for all errors of refraction.

Optical Correction of Myopia.—The optical correction of an error of refraction is accomplished by placing a lens in front of the eye which renders it emmetropic, or enables it to bring parallel rays (a, b, Fig. 46) to a focus on the retina, without any effort of accommodation, and thus renders the vision of distant objects distinct. Since rays diverging from the punctum remotum (R, Fig. 46) are

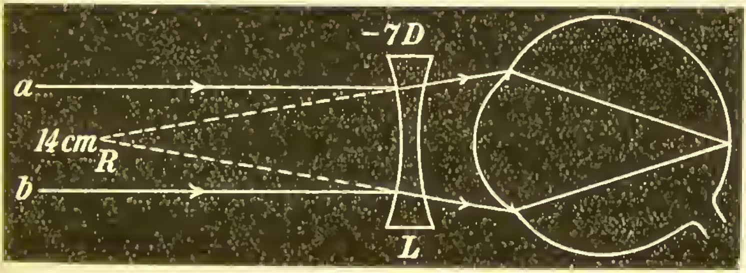


FIG. 46.—Correction of myopia.

brought to a focus on the retina in the myopic eye, the correcting lens, L, must evidently give to parallel rays such a degree of divergence before they pass into the eye, as though they came from this punctum remotum. This lens must therefore be a concave or diverging lens, and its principal focus must be at R; that is to say, the focal length of the lens must be equal to the distance of the far point from the eye, in this case 14 cm. The focus of the glass and the punctum remotum of the eye are then identical; and therefore, parallel rays, after passing through the glass, will have a divergence, as though they came from the punctum remotum, and will form an exact image of the distant object on the retina. It is evident that the glass will also make the rays emerging from the eye parallel. The number of the glass, in this case, −7 D ($= \frac{100}{14}$), will indicate the degree of the myopia—*i.e.*, by how many dioptres the refracting power of the eye is in excess of that of an emmetropic eye. The longer the eye-ball the shorter is the distance of the far point from it; and therefore the shorter must be the focal length of the correcting lens, and the higher must be its number. The degree of myopia therefore increases with the elongation of the eye-ball.

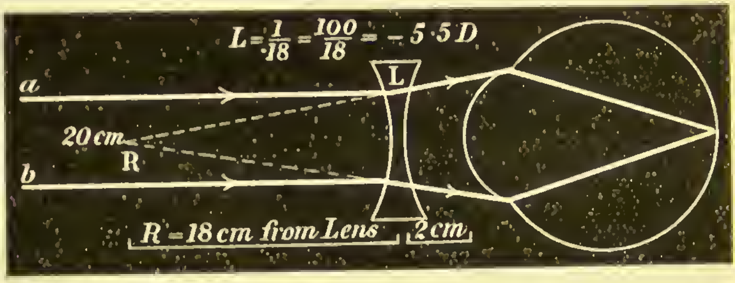


FIG. 47.—Effect of the position of the lens in the correction of myopia.

In the explanation of the correction of myopia given above, it is assumed that the correcting glass is in contact with the cornea. In practice, however, the glass is placed a short distance in front of the cornea, and consequently, must be stronger than the theoretical correction. For example: if the punctum remotum (Fig. 47) be situated at 20 cm. from the eye, then the number of the correcting lens in contact with the eye, and the real measure of the myopia, will be — 5 D, because the focal distance of this lens is 20 cm. ($\frac{100}{20} = 5$). But if, in the above case, the distance from cornea to glass be 2 cm., the required lens in practice will be — 5·5 D ($\frac{100}{18} = 5·5$). Evidently, the further the lens is from the eye the stronger it must be; and it is therefore advisable that correcting lenses should be worn at the same distance from the eye as are the trial lenses when used to measure the degree of ametropia. In the example just given the difference between the theoretical and practical amount of myopia is very slight, but it becomes greater the higher the myopia. In a theoretical M. of 20 D, the lens required at 2 cm. would be — 33 D.

Diagnosis and Determination of the Degree of Myopia.—The degree, or amount, of myopia, may be determined either objectively by the ophthalmoscope, or subjectively by means of the trial-lenses and test-types.

Subjective Method.—Examining each eye separately, we find the correcting glass by placing our patient as directed in the section on Acuteness of Vision (p. 27). Having first tested V. without a glass, a weak concave trial-glass is then placed before the eye under examination, and higher numbers are gradually proceeded to, until that glass is reached which gives the eye the best distinguishing power for the types. In order to save time, the distance of the far point can be found approximately with small print, and the degree of M deduced. A lens a little lower than this may be taken to commence with. We often find that there are several glasses, with each of which the patient can see equally well. *The weakest of these is the measure of his myopia.* When a higher glass than this is used the patient may still see well, but he does so only by an effort of accommodation (*i.e.*, the crystalline lens has to be made more convex, in order to compensate for the excessive concavity of the glass placed in front of the eye), and the glass employed represents then, not merely the myopia present, but also this accommodative effort. It is a serious mistake to prescribe too strong concave glasses for a myopic individual, as will be seen further on

THE OPHTHALMOSCOPIC METHODS will be explained in detail in chapter iv., and merely require to be mentioned here.

Direct method at a distance.—The retinal vessels are visible and appear to move in the opposite direction to the motion of the observer's head.

Indirect method.—The optic disc appears to increase in size when the object lens is drawn away from the patient's eye.

Direct method.—The fundus and vessels are indistinct, and the lowest concave glass which makes them distinct is the measure of the myopia.

Retinoscopy.—With a plane mirror the shadow moves against the direction in which the mirror is rotated, provided the observer is further from the patient's eye than the far point of the latter.

The Amplitude of Accommodation in Myopia.—The myopic eye has an excess of refractive power (r) as compared with the emmetropic eye; therefore, in calculating its amplitude of accommodation, this excess must be subtracted from the positive refractive power (p), which would be required to adapt the emmetropic eye to the same punctum proximum; or, in other words, the myopic eye has need of less accommodative power than the emmetropic eye, because, even at rest, it is adapted for a distance (R., its punctum remotum) for which the emmetropic eye has to accommodate; hence in myopia

$$a = p - r.$$

For example: a myope of 4 D who can accommodate up to 11 cm. ($p = \frac{100}{11} = 9$ D) has an amplitude of accommodation of $9 - 4 = 5$ D.

Range of Accommodation in Myopia.—In myopia both R. and P., and therefore the range of accommodation, are brought closer to the eye. The range is also shortened as can be seen from Fig. 48, which shows the range of Ac. with an amplitude of 8 D, in Em., and in M. and H. of 3 D respectively. In this case R, is known, from the refraction $\left(R = \frac{1}{r} = \frac{1}{3} = 33 \text{ cm.}\right)$; it remains therefore only to determine P. We saw above that in M. $a = p - r$, therefore $p = a + r = 8 + 3 = 11$ D, and $P. = \frac{1}{p} = \frac{1}{11} = 9$ cm.

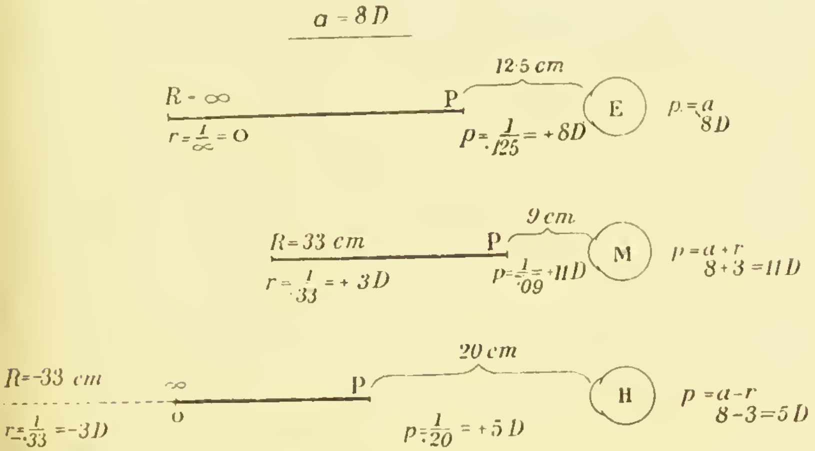


FIG. 48.—Range of accommodation in emmetropia (E.), in myopia (M.), and hypermetropia (H) of 3 D. each, the amplitude of accommodation in all cases being 8 D.

The Angle γ in Myopia.—In myopia, owing to the length of the eyeball, the cornea is cut closer to its centre by the visual line (M. V., Fig. 49) than in emmetropia; or, by displacement of the macular region the visual line and the optic axis (A O) may coincide; or, the cornea may even be cut to the outside of its centre by the visual line. In any of these cases, but especially in the latter, the effect will be that of an apparent convergent strabismus.

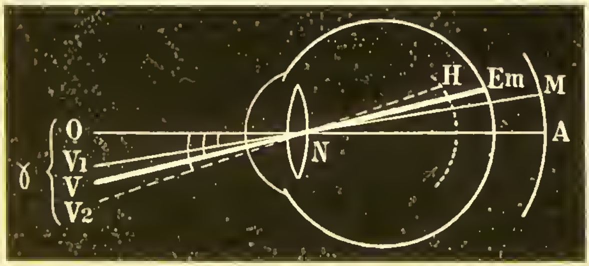


FIG. 49.—Angle γ in emmetropia (Em.) myopia (M.), and hypermetropia (H.).

Etiology.—Myopia is rarely congenital. Infants are hypermetropic, but as they grow the eye tends to become less hypermetropic, emmetropic, or in some cases myopic. Myopia is almost wholly a result of civilisation, and its development and progressive increase is due to the use of the eyes for near work, such as reading, sewing, drawing, etc., which causes elongation of the antero-posterior axis of the eye. It is more common in cities than in the country, and occurs especially in the higher schools, among professional classes, and those occupied with fine work. Opinions are divided as to the way in which close work causes myopia. Some look upon the effort of accommodation as the cause, while others attribute it to the pressure exercised on the eyeball by the recti or oblique muscles during convergence. Heredity also plays a certain part which, however, is not quite clear; but, it would seem that some anatomical or constitutional predisposition must be transmitted to the offspring. Finally, the higher degrees of myopia are very constantly complicated with disease of the posterior pole of the eye (called by some posterior sclero-chorioiditis, and regarded by them as an inflammatory condition), and how far this disease is either the consequence or the cause of the elongation of the globe has yet to be decided.

It should also be stated that anything which encourages approximation of objects to the eye such as defective print, bad light, or indistinctness of vision, *e.g.*, astigmatism, and nebulæ of the cornea, may act as indirect causes. The development of myopia may also be assisted by anything which tends to produce congestion of the head and eyes, such as stooping over books, as a result, for instance, of badly constructed school desks. In rare instances, myopia has been observed to develop or increase considerably after a severe illness. That it is not always due to close work, is shown by the facts that high degrees of myopia are very occasionally met with in young children before they have begun to use their eyes much for near objects; and that the worst cases may sometimes be met with in agricultural labourers, who have done little or no close work.

Myopia, as a rule, first shows itself from the eighth to the fifteenth year, and is apt to increase, especially during the early years of puberty. After this the majority of cases remain stationary, but others continue to increase during the whole lifetime, either periodically or regularly, and may reach 30 D or more.

Simple, or Non-Progressive Myopia.—In this variety the M ceases to increase when the body has reached its full development, and does not, as a rule, go beyond three or four dioptres. The eye is perfectly sound and presents no disease of the fundus, except occasionally a slight crescent at the outer side of the optic disc (see below). This form of myopia is sometimes regarded as a harmless adaptation of the eye to the requirement of civilisation, and as being different in its etiology from the progressive form which is a true disease. Unfortunately it is not possible to distinguish with certainty one form from the other in the earliest stage. But if a patient of sixteen years of age or more, have a low degree of M., say only of 2 D or 3 D, and especially if there be no crescent, one may be fairly confident that the M. will become stationary when the patient is fully grown.

Spasmodic Myopia—that is to say, M. due to spasm of accommodation—is a condition which is not uncommon, and one which is frequently seen, during the transition of H. or Em. into M. The M. disappears under atropine, only to return when the use of the latter is discontinued.

Symptoms of Myopia.—The symptoms of M., apart from the complications which occur in the high degrees, and which will be dealt with later on, are dependent on the optical error of the eye, and are very few. Distant vision is impaired according to the degree of M. present, but many short-sighted people half close their eyes in order to diminish the size of the diffusion circles on the retina, and they are thus enabled to see a little better. It is this habit which has given rise to the term myopia (p. 45). The smallest print can be distinguished with great facility, at or within the near point; and as the retinal images are larger than in emmetropia and consequently require less illumination for their perception, short-sighted persons are much given to reading in bad light. If the patient reads at his far point no accommodation is necessary, and for a nearer point the accommodation being less than in emmetropia, one of the stimuli to convergence is deficient, and in some cases this leads to latent, or even to absolute divergence (see Insufficiency of Convergence (chap. xviii.).

The particles which normally float in the vitreous humour are rendered more noticeable by the larger shadows which they cast on the retina; and this is one of the reasons why myopic people are so frequently troubled by black spots (muscæ volitantes) before their eyes. That short sight improves with age, or is the strongest kind of eye, is a fallacy which owes its origin to the absence or delayed onset of presbyopia in myopic people; and also to the fact that, in low degrees of myopia, the vision may improve a little at a distance owing to the small size of the pupils in old people, or to the slight diminution in the refractive power of the lens which occurs at about sixty years of age (cf. Presbyopia).

Progressive Myopia frequently becomes complicated with Organic Disease, and to the more serious cases the term **Pernicious Myopia** may be applied. The following are the forms of organic disease met with :—

1. *Posterior Staphyloma, or Myopic Crescent.*—This condition is recognised by the ophthalmoscope as a more or less extensive white crescent at the outer circle of the optic papilla.

Fig. 50 explains the manner in which it arises. The bulging of the eyeball, at ×, takes place at the posterior pole, in the direction of the axis A X. The chorioid *c* becomes drawn towards the temporal side, and the optic nerve appears to be displaced in the opposite direction. The chorioid is, consequently, drawn over the edge of the scleral opening at the nasal side at *n*, while it becomes detached and drawn away from it at the outer side at *t*, the portion of sclerotic thus exposed appearing as a white crescent at the temporal edge of the disc (Fig. 51). As the bulging increases, with increase of the myopia, it extends to the nasal side of the nerve as well, the chorioid also becoming atrophied ; and the posterior staphyloma is then seen with the ophthalmoscope completely surrounding the disc, but always larger at the temporal side. The stretching of the retina may, in extreme cases, derange its functions and increase the size of the blind spot. The disc itself appears oval, owing to the oblique position, which the nerve head acquires (Fig. 52).

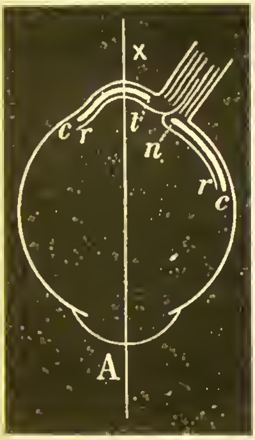
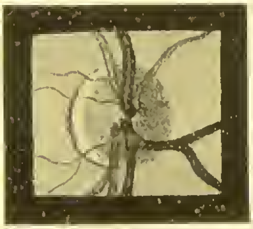
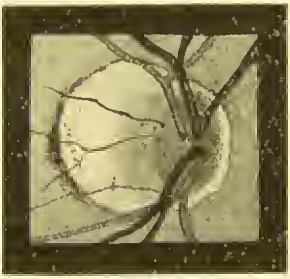


FIG. 50. — Explains formation of myopic crescent.



L.W.

FIG. 51. — Small myopic crescent. M. = 4D.



L.W.

FIG. 52.—Large posterior staphyloma surrounding optic disc. M. = 9D.

The size of the staphyloma generally corresponds with the degree of M. although exceptions to this occur. Every case in which a small crescent is present is not to be regarded as serious; for much here depends on the age of the patient and the degree of the myopia. The younger the patient and the higher the myopia, the more serious is the outlook.

2. *Chorioidal Degeneration in the Neighbourhood of the Macula Lutea.*—This should always be carefully looked for, as the region of the yellow spot is very liable to disease in the worst cases of progressive myopia. The disease seems to begin in the chorioid, giving the appearance of small cracks or fissures, which, at a later period, develop into a patch of chorioidal atrophy. The retina at the yellow spot becomes gradually disorganised, and very serious disturbance of vision, associated in the early stages with metamorphopsia, is the result, the patient being disabled from reading, although, as the periphery of the fundus is usually sound, he can find his way about freely. Treatment can do little here. Abstention from use for near work, and the wearing of dark glasses are to be recommended.

3. *Chorioidal Exudation in the Neighbourhood of the Macula Lutea.*—A small grey spot of exudation may appear in the chorioid at this place, accompanied by loss of sight for reading. These cases are often amenable to active mercurial treatment, when sight may be restored. Should the case be neglected or run a bad course, vision will be permanently damaged from secondary chorioidal degeneration.

4. *The Black Spot in Myopia.*—This disease also attacks the chorioid in the region of the yellow spot, and causes a loss of central vision, as in the two previous forms of disease. The appearance shown by the ophthalmoscope is that of a black spot, usually quite circular and with a defined margin. In the early stages its size is much smaller than that of the papilla, but later it often attains a dimension of two papilla diameters, or more. The spot is rarely

of an equal intensity of blackness all over, but towards its centre a faint reddish hue often shines through in places. At a later stage the black spot becomes surrounded by a narrow whitish border, while towards its centre it becomes less black, and finally greyish or even white, its margin remaining black. Although small hæmorrhages, which often occur in the neighbourhood of the black spot, gave rise to the opinion that the black spot itself was the result of hæmorrhage, yet this seems not to be so, as the investigations of E. Lehmus have shown. The disease consists in a proliferation of the pigment epithelium, combined with a gelatinous exudation, which in the case examined had attained a thickness, at the centre of the black spot, of two-thirds that of the chorioid. The chorioid was but very slightly altered, and the glass membrane was quite normal. At the margin of the proliferating region the pigment epithelium was found to be paler or even quite free of pigment. The black spot very gradually, in the course of years, attains its ultimate dimension, and then very slowly retrogresses, until finally its place is taken by a greyish or bluish-white scar. Treatment is of no avail, and central vision does not become restored.

5. *General Chorioidal Atrophy.*—In advanced cases of pernicious myopia, large patches of chorioidal atrophy, other than the crescent, are often present, chiefly in the region of the posterior pole, but often also towards the periphery of the fundus. The vitreous humour in these cases is more fluid than normal, and usually contains many opacities. Treatment by means of sub-conjunctival saline injections is occasionally of use in clearing up the vitreous humour, and thus effects some improvement of vision. The eyes should not be used for near work, and dark glasses should be worn.

6. *Hæmorrhage in the Retina at the Yellow Spot* may occur, and when the hæmorrhage becomes absorbed the macula lutea may not recover its function, owing to the delicate retinal

tissue having been seriously damaged. Yet we often meet with cases of this kind which do regain their former vision. Rest of the eyes and dark glasses should be prescribed.

7. *Detachment of the Retina.*—This is a frequent, and most serious complication of progressive myopia, and sometimes leads to secondary cataract and even to shrinking of the eyeball (Phthisis Bulbi). It will be considered in the chapter on Diseases of the Retina.

In high degrees of M. the eyes are unduly prominent, and the sclerotic appears flatter at the sides; the pupils are usually large and the anterior chamber deep, owing to the slight development of the ciliary muscle in consequence of the non-use of accommodation.

Functional Anomalies attending Progressive Myopia. –

(*a*) *Insufficiency of Convergence* is almost always associated with progressive myopia, and is the result of two causes, namely the diminished impulse to convergence produced by the absence of accommodation, and the mechanical difficulty introduced by the elongation of the eyes. The insufficiency of convergence may be only latent, or it may lead passively to absolute divergent strabismus (see chap. xviii.).

(*b*) *Cramp of Accommodation* is often present and causes an apparent increase in the Myopia (see p. 53).

The Management of Myopia.—In view of the tendency to increase, to which, especially during adolescence, nearly every case of short-sight is liable, and of the fact that in a given case we cannot tell to what extent this increase may go, and, finally, as the high degrees almost invariably lead to disease of the eye, the management of myopia, including the prescribing of glasses for it, is one of the most important matters with which we have to deal.

The Prescribing of Glasses in Myopia.—It is not necessary to prescribe glasses for very slight degrees of myopia (up to

1·0 D or 1·5 D); yet, should the patient desire to wear correcting glasses for distant objects, there can be no objection to it. But for cases of myopia of 2·0 D or more, unless presbyopia be also present, it becomes very desirable to prescribe glasses which fully correct the myopia, to be worn constantly—*i.e.*, for both distant and near objects; and, should the myopia increase, to accordingly increase from time to time the strength of the glasses.

This has not always been the teaching on this point, and even yet many ophthalmologists do not prescribe fully correcting glasses for their myopic patients, especially for near work. It has been held, that any effort of accommodation, which might be caused by fully correcting concave glasses, would promote the tendency to increase of the short-sight, and to chorioidal disease. In short, it was regarded as important to save the myopic eye every effort of accommodation in so far as possible. The usual practice was to order a glass from 0·5 D, to 2 D less than the full correction for distant vision; while, for near work, either no glasses were allowed, if the myopia was of low degree, or, if of medium or high degree, a separate pair of spectacles, of such strength as would merely enable the patient to read ordinary print at about 30 cm. from his eyes, was given. It was also the practice to restrict the use of the myopic eye for near work to a limited number of hours daily, with intervals of rest, or even to interdict all near work absolutely for a period of months at a time. The main object of the reading-glass was—the patient being enabled thereby to hold near objects farther from his eye—to diminish the angle of convergence of the optic axes, and thus to reduce the pressure of the orbital muscles on the eyeball during convergence, a pressure which it is considered promotes the elongation of the globe.

We now know, on the one hand, that the action of the muscle of accommodation does not produce a pull on the chorioid farther back than the equator of the eyeball, while it is at the posterior pole that the diseased processes in myopia commence. Nor does the ciliary muscle by raising the tension of the eye, nor in any other way, cause an elongation of the eyeball. Hence, there is no reason to spare the healthy myopic eye any ordinary effort of accommodation. Indeed, it is reasonable to think that if normal efforts be required of the ciliary muscle, its more healthy tone will improve the general healthy nutrition of the uveal tract, and consequently will tend rather to avert morbid changes in it.

On the other hand, the diminution of the angle of convergence at near work is a truly important matter, for the reason above stated; but it is more effectually provided for by full than by partial correction.

Practical experience is here even more valuable than theory, and it shows that in a large majority of those patients whose short-sight has been fully corrected in youth, and who have worn their spectacles constantly for a number of years, the myopia in many instances has not increased at all, while in a large proportion the increase will have been moderate, and in but a small proportion marked pernicious progress will be noted. In short, the tendency to increase of the myopia, and to organic disease, is less than in those myopes who have either worn no glasses, or only partially correcting glasses.

Well-fitting, properly centred spectacles are much to be preferred to folders, which are difficult to keep correctly centred before the eyes. Any astigmatism present should always be corrected. Patients whose eyes are healthy, and who wear constant full correction, may be permitted, and even encouraged, to use their eyes freely for near work, always keeping the work as far from the eyes as possible, to diminish the angle of convergence. With this latter object in view, too, well printed books, ample light, and suitable reading- and writing-desks should be provided in all educational establishments, and for home studies.

But in prescribing the full correction for constant wear to young short-sighted persons, we meet with some difficulties. The first of these is due to the range of accommodation, which is imperfect in the myopic eye, and consequently the patients may complain of painful accommodative sensations when first using their fully correcting lenses for near work, and sometimes they decline to persist in the attempt. These complaints are more likely to be made by patients of about twenty years of age or more, whose habit of use of their eyes (relative amplitude of accommodation, and degree of convergence) has become more or less confirmed, and in whom the power of accommodation has naturally diminished to an appreciable degree, rather than by persons of from twelve to seventeen years of age. Patients should be encouraged, in spite of discomfort, to continue for some time longer to read, etc., with the full correction, when, very often, the relative amplitude of accommodation will gradually improve, and the discomfort will cease. Or, a lower number than the full correction may be ordered, and the strength gradually increased, until, in the course of some weeks or longer, the full correction can be worn for near work with ease.

Operative Cure of Myopia.—This consists in diminishing the refraction of the eye by the removal of the crystalline lens. Some surgeons simply extract the clear lens, while the majority now, including the authors, perform discission, followed, in a few days, by the evacuation of the swollen and cataractous lens, and in some cases by a subsequent capsulotomy. A larger number of operations than this is apt to be injurious; moreover, the swollen lens should be removed before the tension of the eye becomes increased. For both of these reasons, therefore, simple discission without extraction is inferior to the other method. There are grounds for suspecting that, in these highly myopic eyes, the tendency to retinal detachment is increased by the operation, although this has not been shown by statistics.

The operative cure of myopia is not to be recommended except for cases of 12·0 D and more; nor should it be performed where there is such serious disease of the fundus or vitreous humour as would render any improved use of the eye on conclusion of the treatment unlikely. Active chorioidal disease is regarded as a contra-indication, but small retinal hæmorrhages, even if they be near the macula lutea, need not be so regarded. The best time of life for the cure is in childhood or in early youth, but it can be successfully undertaken at a much later period. In the myopic eye the nucleus of the lens undergoes sclerosis to a less extent than in hypermetropia or in emmetropia, and hence in it discission is less apt to be followed by high tension or other complication, even when performed in middle age.

The advantages gained by the patients from the operative cure of their myopia are very great. Not merely do they become sometimes emmetropic, but the acuteness of vision is usually increased in a remarkable degree, being occasionally even double or treble that which previously existed with the correcting glasses. This improvement is chiefly due to the increased size of the retinal images. The reduction in the refraction is much greater in these cases, than after removal of the lens for cataract in an emmetropic eye. In the latter case a convex lens of 10 D is required to correct the eye for distance, whereas a myope of 20 D most commonly requires no correction for distance after the removal of his lens. The explanation of this is simple. When the lens is removed, the only refracting surface is then the cornea, the focal length of which is approximately 31 mm.; a myopic eye therefore which is 31 mm. long would, when deprived of its lens, bring parallel rays to a focus on the retina and would require no correction for distance. Since the average focal length of the emmetropic eye is 24 mm. this myopic eye would be $31 - 24 = 7$ mm. longer. Now it can be easily shown that, in the complete eye containing the lens, every millimetre of increase in length corresponds to an increase of 3 D of refraction, consequently in this case before operation, when the lens was present, the refraction would have been increased by $3 \times 7 = 21$ D, a result which agrees in most cases with practice.

In the absence of the lens an increase of 1 mm. in length only augments the refraction by about 1·5 D, that is to say, only half the amount which the same increase of length produces in the complete eye. A simple rule therefore for finding approximately what the refraction will be, after removal of the lens, in a given case of myopia, is to take half the number of dioptres of the myopia and subtract it from 10, if the result be positive a plus lens will be required after operation, and if negative a concave lens. For example, a myope of 10 D will require a + 5 D for correction after operation, $10 - \frac{10}{2} = 5$, and a myope of 30 D will remain with 5 D of myopia, $10 - \frac{30}{2} = -5$. In practice cases sometimes occur which do not agree with theory, and for this there are reasons which cannot be fully entered into here, but amongst them is the difficulty of an exact estimation of the refraction in high M. and the possibility of the M. being, not merely axial, but also caused by shortening of the focal length of the dioptric system.

The mere possibility that detachment of the retina may be caused, or hastened, by the operation is a sufficient reason for limiting the operation to one eye. It is wiser not to operate on the second eye, even though a successful result may have been obtained in the first, and though the patient, as often happens, may desire it. The eye which has been operated upon will serve for distant vision and its fellow for near work, and thus, where the eye after operation becomes emmetropic, the patient is rendered independent of glasses. It has not been proved that removal of the lens arrests the progress of myopia

HYPERMETROPIA.

Definition, and Optical Causes.—In Hypermetropia the retina lies in front of the principal focus of the dioptric system, and therefore parallel rays of light (*a*, *b*, Fig. 53), falling into the hypermetropic eye (*E*), do not meet on the retina, but converge towards a point (*c*) situated behind it.

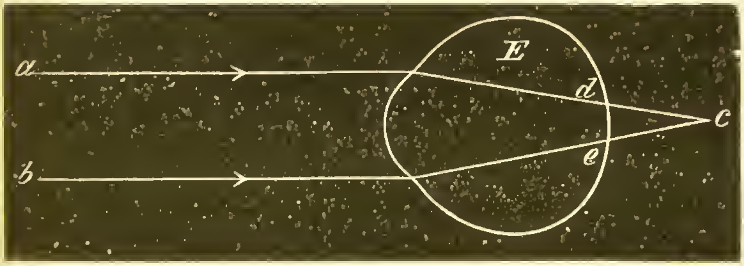


FIG 53.

As compared with emmetropia the refraction of a hypermetropic eye is diminished. It may be caused by displacement of the retina forwards, from shortening of the eyeball (Axial H.), or by elongation of the focal length of the dioptric system through flattening of the cornea (Curvature H.), or absence of the lens.

Far Point (R.) of the Hypermetropic Eye.—Since parallel rays do not unite on the retina, but produce there a circle of diffusion (*d*, *e*, Fig. 53), the hypermetropic eye cannot see distant objects distinctly, and if an object be brought closer, its focus will lie still further behind the retina (§17, chap. i.). There is therefore no position between infinity and the cornea, from which rays of light would unite on the retina of the hypermetropic eye; in other words, there is no real far point. What kind of rays then will come to a focus on the retina of a hypermetropic eye? The answer will be found by considering the course of the rays emerging from the eye. Since the refraction is deficient or, what is the same thing, since the retina lies in front of the principal focus F. Fig. 54, (see §18, chap. i.) rays coming from any point (*c*), will not even be rendered parallel, but will pass out as divergent rays (*f*, *g*), and they can therefore never meet to form a real conjugate focus, or far point. But they will diverge as if they came from a point R, situated behind the eye, which point is the virtual conjugate focus of the point *c* on the retina. R is the virtual far point. It is situated behind the eye, is negative, and cannot be measured directly as in myopia. Conversely, if the rays *f*, *g*, enter the eye with a convergence towards R, they will unite on the retina. The hypermetropic eye therefore is only adapted, when at rest, for convergent rays. The shorter the eyeball, the further the retina is from F, and the greater the divergence of the emerging rays, and consequently the shorter will be the distance of the far point, and the higher the error of

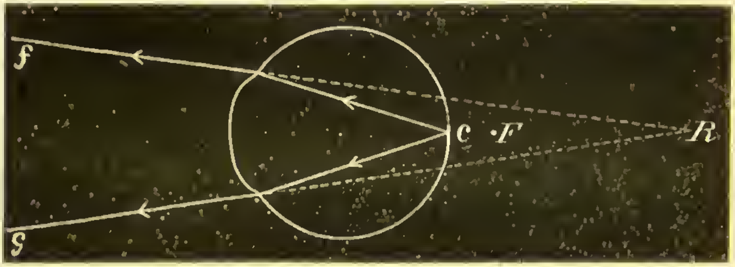


FIG. 54.

refraction. In hypermetropia, as in myopia, $r = \frac{1}{R}$, but here R is negative, and therefore r, the error of refraction, is also a negative quantity.

Optical Correction of Hypermetropia.—In order to correct hypermetropia—that is, to render the eye emmetropic, so that parallel rays may be brought to a focus on the retina (*c*. Fig. 55)—a lens must be placed in front of the eye, which will give to the parallel rays (*a*, *b*) before they enter it a convergence towards its far point, R. This lens must therefore be a converging or + lens, and its focal length must be equal to the distance of R from the eye (in this case 25 cm.). The negative error, or deficiency in the refraction, is corrected by a + lens (L), which increases the refraction, and thereby shortens the focal length of the eye so as to bring the focus on to the retina. The shorter the antero-posterior axis of the eyeball, the closer is R (see p. 64), and the shorter therefore must be the focal length of the correcting lens. That is to say, the correcting lens must be stronger, and the hypermetropia consequently greater, when the eye is shorter.

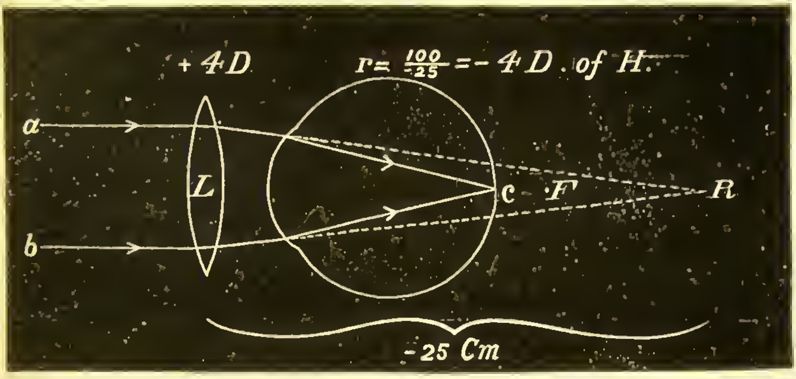


FIG. 55.—Correction of hypermetropia. R = far point, r = error of refraction.

It is evident that the further the lens (L) is from the cornea the greater is its distance from R, and therefore the weaker the lens which is required. This is the reverse of what takes place in myopia (p. 48).

Hypermetropia can also be corrected by an effort of accommodation, in which the increased convexity of the crystalline lens within the eye takes the place of the correcting glass. In the case represented by Fig. 55, an accommodation equivalent to 4 D would be required.

Determination of the Degree of H. SUBJECTIVE METHOD BY TRIAL-LENSES AND TEST-TYPES.—Since accommodation tends to correct hypermetropia, care must be taken in drawing conclusions from this method of examination. If the acuteness of vision be improved by a convex lens, H. is present, but it may be found that, with a lens of some dioptres less, the eye will see equally well; this means that an effort of accommodation supplements the weaker lens placed before the eye. As higher lenses are proceeded to, the effort of accommodation is relaxed, until, finally, the strongest lens with which vision is still at its best is reached, when, it may for the present be assumed, no further effort of accommodation is made, and this lens then represents the whole error of refraction.

In low degrees of hypermetropia, accommodation frequently corrects the whole of the H. When such an eye is found to have full vision without a glass, a beginner may fall into the error of regarding it as emmetropic; but if he will take the precaution of placing a low convex lens in front of it, and then finds that the acuteness of vision remains as good as without the glass (because the effort of accommodation is now relaxed), he will avoid this mistake, unless there should be tonic cramp of accommodation, which might partially, or even completely, mask the hypermetropia.

If a glass a single number higher than the exact measure of the defect be placed before the eye, vision again becomes indistinct, because the rays are then brought to a focus in front of the retina, and a circle of diffusion is formed on the latter. The eye, in fact, is put by such a glass in a condition of myopia. Therefore *the strongest convex glass with which a hypermetropic eye can see distant objects (the test-types) most distinctly is the glass which corrects its hypermetropia, and is the measure of the latter.* Very commonly it is only the manifest hypermetropia (*vide infra*) which is ascertained by this method, unless the accommodation has been previously paralysed by atropine.

OPHTHALMOSCOPIC, OR OBJECTIVE TESTS. *Direct Method at a Distance.*—The retinal vessels are visible, and appear to move in the same direction as the motion of the observer's head.

Indirect Method.—The optic disc appears to diminish in ize as the lens is withdrawn from the patient's eye.

Direct Method.—The strongest convex glass with which he fundus and vessels can be seen distinctly is the measure f the H.

Retinoscopy.—With a plane mirror the shadow moves in he same direction as that in which the mirror is rotated, hat is to say, with the mirror.

Amplitude of Accommodation in Hypermetropia.—When at rest the fraction of the hypermetropic eye is deficient, consequently r must be gative ($-r$), and the amplitude of accommodation must include the rrection required to adapt the eye to infinity ; therefore the formula r the amplitude of accommodation (p. 27) becomes

$$a = p - (-r) = p + r.$$

For example: if the punctum proximum of a hypermetropic eye of D be at 30 cm., what is the amplitude of accommodation? 5 D r) is necessary in order to make the eye emmetropic, and to commodate the emmetropic eye to 30 cm. 3·25 D ($\frac{100}{30} = 3·25$) is quired. Hence $a = 3·25 + 5 = 8·25$ D.

Range of Accommodation in H.—In hypermetropia a part of the ient's amplitude of accommodation is used to correct the error of action, the remainder only being available for the purpose of pting the eye for a near point. It follows, therefore, that, with same amplitude of accommodation as an emmetrope, the near point be further away from the eye in hypermetropia. This is shown in 48, which represents the ranges of accommodation in emmetropia

(E.), myopia of 3 D (M.), and hypermetropia of 3 D (H.), the amplitude being 8 D.

The Angle γ in Hypermetropia.—In hypermetropia, as in emmetropia, the cornea is cut to the inside of its axis by the visual line; but in hypermetropia the angle which the visual line forms with the optic axis is greater, owing to the shortness of the eyeball, the effect of which is to increase the angular distance between the macula lutea and the optic axis (*O A*, Fig. 49). Consequently, in extreme cases, when the two visual lines of a hypermetropic individual are directed to an object, the axes of the corneæ may seem to diverge, and thus the appearance of a divergent strabismus will be given (see apparent strabismus, chap. xviii.).

Varieties of H. in Relation to Accommodation.—

Hypermetropes endeavour to correct as much of the error of refraction as possible by accommodating, and the ciliary muscle is thus kept persistently contracted.

This spasm is not, or may be only partially, relaxed when the correcting convex glass is held before the eye, and consequently the whole or part of the hypermetropia may be masked by the cramp. That part of the hypermetropia which is thus masked is called latent (Hl.), while the part which is revealed by the convex glass with which the test-types are read is called manifest (Hm.). The entire hypermetropia is made up of the latent and manifest H. (H. = Hm. + Hl.).

If the Hm. cannot be corrected by accommodation it is called absolute H., if it can be so corrected it is know as facultative. For example, a patient without glasses ha $V = \frac{6}{18}$, and with + 1·5 D, $V = \frac{6}{5}$; with 2·5 D also, V = but when accommodation is paralysed the H. is found to b 4 D. In this case the total H. is 4 D, the Hm. is 2·5 D, which 1·5 D is absolute and 1 D facultative, while there 1·5 D latent H. The relation between the Hm. and H varies with the age and general health of the individual.

When the spasm persists so that the accommodation cann be relaxed, the vision is then made worse, even by a wea convex glass, thus simulating emmetropia. In this case say that the whole hypermetropia is latent. Or, in extreme cases of accommodative spasm, parallel rays may be united in front of the retina, and the eye made apparently myopic, distant vision being capable of improvement by concave glasses (see p. 53). Some of these patients cannot maintain a sustained view of an object at any distance without suffering pain in and about the eyes. Examination with the ophthalmoscope, or paralysis of accommodation with atropine, will enable the surgeon to avoid mistakes.

In order to relieve this cramp, or to ascertain the real state of the refraction, especially in children, atropine must be freely instilled; and it will often be necessary to keep the accommodation paralysed for some days, and to commence the use of the correcting spectacles before the effect of the atropine begins to wear off. In this way a recurrence of the spasm may be often prevented.

As life advances, and the power of accommodation diminishes, the manifest part of the hypermetropia increases, while the latent part decreases, until finally Hm. = H.

Etiology.—Typical hypermetropia is practically always axial, *i.e.*, due to a short eyeball. Children are hypermetropic at birth, but with the growth of the body the eye develops and becomes less hypermetropic, or emmetropic, or even myopic. So that the hypermetropic eye may be regarded as an undeveloped organ, and indeed the highest degrees of H. are met with in very small (microphthalmic) eyes, which are often the subjects of congenital malformations. The eyes of animals and of uncivilised nations are also hypermetropic. When the period of growth ceases, any H. which may then exist remains stationary. There s never any progress, as in myopia; and very high degrees are rarely seen, even 12 D being unusual. Hypermetropic yes are moreover healthy, and free from the complications which follow mechanically from the change in shape of the myopic eye.

Symptoms of H.—These depend chiefly on the relation of the H. to the amplitude of accommodation, and will be understood from what has been already stated. Both distant and near vision may be perfect, or near vision alone may be defective, or both may be imperfect. In high degrees of H. patients sometimes hold the book close to the eyes in order to obtain larger retinal images, but they cannot read the smallest type with the ease and fluency of the myope. Slight redness and veiling of the edges of the optic disc with tortuosity of the retinal vessels is sometimes seen. Other consequences are accommodative asthenopia, and convergent strabismus. Hypermetropic eyes show increased curvature of the sclerotic at the outer side, when the eye is rotated inwards, the pupils are smaller than in Em., and the anterior chamber shallow.

Accommodative Asthenopia (*α, priv.; σθένος, strength; ὤψ*).—This is the name given to the group of symptoms which occur when the patient is unable to sustain the accommodative effort required for near vision. A hypermetrope, having used up part of his accommodation for distance, has for near objects actually less at his disposition than an emmetrope. Hence, hypermetropic people often complain of inability to sustain accommodative efforts for near objects for any length of time. After reading, sewing, etc., for a short time, sensations of pressure in the eyes, and of weight above and around them come on, and the words or stitches become indistinct, and cannot be distinguished, and the efforts to see are attended with frowning and even with facial contortions. The work must then be interrupted, and after a few minutes' rest it can be resumed, but must soon again be given up. After a Sunday's rest the patient is often able to get on better than on the previous Saturday. These symptoms depend simply upon inability of the ciliary muscle to answer to the excessive demands made upon it.

Accommodative asthenopia often appears suddenly during or after illness, the explanation being that, although hypermetropia had always existed, yet in health the ciliary muscle was equal to the great efforts required of it, but in sickness it shared the debility of the system in general.

Internal, or Convergent Concomitant Strabismus.—This condition has a certain relation to hypermetropia. It will be treated of in the chapter on the Motions of the Eyeballs and their Derangements (chap. xvii.).

The Prescribing of Spectacles in Hypermetropia.—If a person be found to be hypermetropic, but his acuteness of vision without glasses be good, or as good as he desires, and he complain of no asthenopic symptoms, glasses need not, indeed should not, be prescribed for him. No disease in his eye will result from his going without glasses.

If the patient complain of imperfect distant vision due to hypermetropia, then those lenses which correct the Hm. may be prescribed for distant vision, to be worn either constantly or occasionally, as he may desire. Such a patient is almost certain to complain also of accommodative asthenopia; while many patients will be met with who complain of the latter, yet express themselves as perfectly satisfied with their distant vision. For relief of the asthenopia it is usually enough to prescribe spectacles for near work which will correct the Hm., along with 1 D or 2 D of the Hl., if the latter exist.

If there be excessive cramp of accommodation, glasses to correct the whole hypermetropia should be worn while the eye is under atropine; and afterwards as much of the Hl. as possible, along with the Hm., should be corrected by glasses to be worn constantly.

ASTIGMATISM.

In this form of ametropia the refracting surfaces are not spherical, and consequently, rays of light from a luminous point are not brought to one focus. The defect usually lies in the cornea, and the astigmatism may be regular or irregular.

In *Regular Astigmatism* the directions of the greatest and least curvatures of the cornea are always at right angles to each other, and usually fall precisely in the vertical and horizontal meridians, the meridian of greatest curvature being most frequently the vertical. The surface of the cornea then resembles the back of the bowl of a spoon, which is more convex from side to side than from heel to point. Astigmatism is said to be "with the rule" when the meridian of greatest curvature is vertical, and, "against the rule," when this meridian is horizontal. Hence a pencil of rays passing into the eye, instead of meeting at a common focus, is irregularly refracted, those rays passing through the vertical meridian of the cornea being brought to a focus much earlier than those which fall through its horizontal meridian; and therefore at the focus of the former the latter rays form a horizontal streak of light. The interval between the foci of the two principal meridians is called the Focal Interval, and is a measure of the astigmatism.

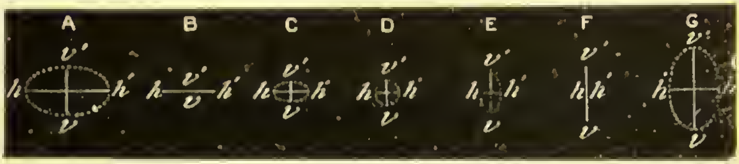


FIG. 56.

Fig. 56 shows the different forms which the image of a point assumes after the passage of the rays through an astigmatic surface.

At A neither vertical (v v') nor horizontal (h h') rays have yet been united at their foci, but the vertical rays are the nearest to their focus; and therefore here the appearance of the image on an intercepting screen, is an oval with its long axis horizontal, as shown by the dotted line. At B the vertical rays have met at their focus, but the horizontal rays not as yet at theirs, the effect being a horizontal straight line. At C the vertical rays are diverging again from their focus, and the horizontal rays have not come to theirs. At D the same conditions exist, only a little farther on, where one set of rays is diverging, the other still converging, but each at the same angle; hence the figure is a circle. At F the horizontal rays have met, and the result is a vertical straight line. At G both sets of rays are divergent, and the figure is an oval with the long axis perpendicular.

There are various kinds of regular astigmatism, according to the position of the two principal foci with reference to the retina, as follows:—

1. *Compound Hypermetropic Astigmatism.*—Both foci behind the retina, that of the horizontal rays (H, Fig. 57) farther back than that (V) of the vertical rays. Hypermetropia in both meridians, but greater in the horizontal.

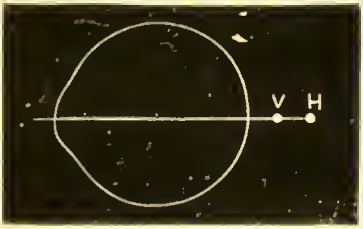


FIG. 57.

2. *Simple Hypermetropic Astigmatism.*—The focus of the vertical rays (V, Fig. 58) on the retina (emmetropia in that meridian); that (H) of the horizontal rays behind the retina (hypermetropia in that meridian).

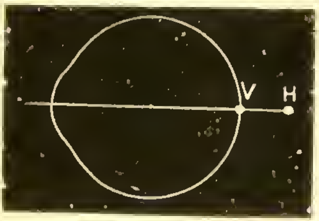


FIG. 58.

3. *Mixed Astigmatism.*—The horizontal focus (H, Fig. 59) behind the retina (hypermetropia in that meridian), and the vertical focus (V) in front of the retina (myopia in that meridian).

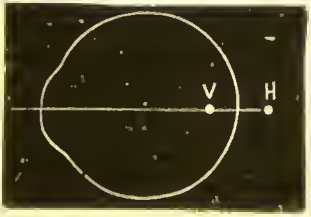


FIG. 59.

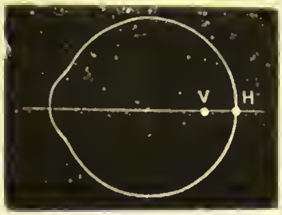


FIG. 60.

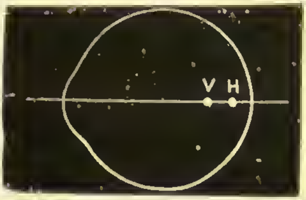


FIG. 61.

4. *Simple Myopic Astigmatism.*—The horizontal focus (H, Fig. 60) on the retina (emmetropia in that meridian), the vertical focus (V) in front of the retina (myopia).

5. *Compound Myopic Astigmatism.*—Both foci in front of the retina, but the vertical focus further forward (V, Fig. 61).

Symptoms of Astigmatism.—We may conclude that an individual is astigmatic if he see horizontal (or vertical) lines, such as the horizontal portions of Roman capital letters, or the horizontal lines in music, or the horizontal rays in Snellen's Sunrise figure (see end of this book) distinctly, while the vertical (or horizontal) lines seem indistinct. We have such a complaint, for example, when the retina is situated at the focus of the parallel rays passing through the vertical meridian of the cornea.

Suppose an eye to be emmetropic in the vertical meridian, and ametropic in the horizontal meridian: we must first consider how a point will be seen by such an eye. The rays of light emitted from the point and passing through the horizontal meridian will not be brought to a focus on the retina, but will produce a blurring of the retinal image of the point at each side; while the vertical rays will unite on the retina, and consequently the point will appear distinctly defined above and below.

A line may be regarded as a number of points, and in order to understand how lines will be seen by an astigmatic eye, such as the above, it is only necessary to arrange a number of points blurred at the sides in vertical and horizontal lines—as at *a* and *b* in Fig. 62.

It is evident at once from mere inspection that the horizontal line will appear distinct, because the rays which diverge from each point of the latter in a vertical plane—*i.e.*, at right angles to the direction of the line—are brought to a focus on the retina; while those rays diverging in a horizontal plane, although not meeting on the retina, do not render the picture of the line indistinct, because the diffusion images resulting from them exist in the horizontal direction, and consequently cover or overlap each other on the line, and therefore are not seen and do not confuse the sight. At the ends of the line only (*b*, Fig. 63) do the diffusion images cause a fuzziness or make the line seem longer than it is. In this case a vertical line (*a*, Figs. 62 and 63) seems indistinct, because, the horizontal meridian being out of focus, the diffusion images existing in that direction are very apparent, as they are at right angles to the edge of the line. On the other hand, in order to see a vertical stripe accurately, it is necessary only that the rays diverging in a horizontal plane should have their focus on the retina; and, therefore, if an individual can only see vertical lines distinctly at 6 metres we know that his eye is emmetropic in the horizontal meridian (and probably myopic in the vertical meridian). We do not, however, hear this complaint as often as might be expected, because simple astigmatism is not so common as one or other of the compound forms.

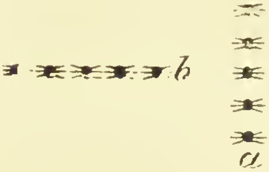


FIG. 62.

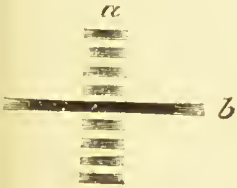


FIG. 63.

Astigmatic people do not generally see very distinctly, either at long or at short distances.

Even in hypermetropic astigmatism the book is very often brought close to the eyes, in order, by increasing the size of the retinal image, to make up for its indistinctness.

Astigmatic individuals frequently suffer much from headache, due to constant effort to see distinctly, and the correction of the astigmatism often cures it.

It has been stated that epilepsy, if not capable of being actually produced by refractive errors, especially by astigmatism, in persons with stable brains, may sometimes have such errors as its exciting cause, where there is already a predisposition to the disease.

All these signs and symptoms appertain to the rather high degrees of astigmatism. Slight degrees may cause no annoyance beyond some indistinctness of vision; and indeed slight degrees of hypermetropic astigmatism often pass unnoticed until late in life, when the accommodation begins to fail. But very low degrees of astigmatism may give rise to symptoms in neurotic individuals. Astigmatism, contrary to rule, or with the axis obliquely placed are the forms most likely to cause annoyance.

We are often led to suspect and to seek for astigmatism when, in examining the refraction with spherical glasses, we are able to bring about some improvement of vision, but cannot obtain normal V. with any glass, while there is no organic disease to account for the defect. Also if, in examining with spherical glasses, we find V. benefited equally by several glasses of considerable difference in power, even perhaps by convex as well as by concave glasses.

The ophthalmoscope affords us an admirable means of diagnosing astigmatism, and of determining its amount. Just as the astigmatic eye cannot see horizontal and vertical lines equally well at the same moment, so is an observer unable to see both the vertical and horizontal vessels in the retina of the astigmatic eye simultaneously, but must alter his accommodation to be able to see first one set of vessels and then the other.

A comparison of the shape of the optic papilla, as seen in the upright and in the inverted images, may also give a clue to the presence of astigmatism. Inasmuch as the fundus oculi is very much magnified in the upright image by the dioptric media through which it is seen, and as this enlargement is greater in the direction of the meridian of shortest focus (meridian of highest refraction), which is most commonly the vertical meridian, a circular object, such as the papilla, will seem to be of an oval shape with its long axis vertical. But in the inverted image, if the principal focus of the lens be closer to the eye than 13 mm. (anterior focus of the eye), the magnification will be less in the meridian of greatest refraction; and here, consequently, the round optic papilla is seen as an oval with its long axis horizontal. If the principal focus of the lens be further from the eye than 13 mm., the magnification again becomes greater in the meridian of greatest refraction, and the oval again becomes vertical. Sometimes the papilla is really of an oval shape, and not round, and then the diagnosis is readily made by observing that in one image it is seen as an oval, while in the other image it is circular. Care must be taken in the indirect method not to hold the lens obliquely, as this would be sufficient to make a circular disc appear oval, the long axis of the oval being in the direction of the axis round which the lens is rotated.

In astigmatic eyes a crescent, similar to that seen in myopia, is often present at the margin of the optic disc. It lies parallel to the meridian of higher refraction.

In cases of corneal astigmatism the image of Placido's disc (see chap. vii.), reflected on the cornea, shows ellipses instead of circles, the short axes lying in the meridian of greatest curvature.

The Estimation of the Degree of Astigmatism and its Correction.—It is evident that to correct astigmatism the ordinary spherical lenses would be of little use, for they affect the refraction of the light passing through them equally in every direction. Cylindrical lenses (p. 14) are therefore employed, which refract light in one direction only—viz., at right angles to their axes.

SUBJECTIVE METHOD.—Although astigmatism is nowadays almost universally estimated by means of the ophthalmoscope, or by the astigmometer (see p. 81), yet in order to give the student a clear idea of the matter in the simplest way, a subjective method for its estimation will be now described, while its objective estimation by aid of the ophthalmoscope (erect image and retinoscopy) will be treated of in the next chapter.

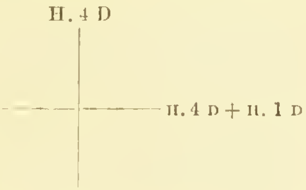
Simple Astigmatism.—Snellen's Sunrise (*vide* diagram at end of book), or some such diagram, is placed at 6 metres from the eye (the other eye being excluded), and the patient is asked whether there be any line which he sees much more distinctly and blacker than the others, and can trace farther towards the central point. If that be so, he must be emmetropic in the meridian at right angles to that line, provided his accommodation be at rest, and ametropic in the meridian corresponding to that line.

In case the horizontal line below at each side be the distinct one, the eye is emmetropic in the vertical meridian, and probably hypermetropic in the horizontal meridian, because the latter is generally that of least curvature. Consequently, a convex cylindrical lens held with its curvature horizontally (axis vertical) before the eye will correct the defect. The highest convex cylindrical glass which gives the patient the best possible distant vision will be the correcting glass. This would be a case of Simple Hypermetropic Astigmatism (As. H.). If the lens required be + 2 D Cyl., it would be As. H. 2 D; and in prescribing for the optician we should write "+ 2 D Cyl. Ax. Vert."

If the central vertical line be the distinct one, then emmetropia exists in the horizontal meridian, and probably therefore myopia in the vertical meridian; and a concave cylindrical lens held before the eye with its curvature vertical (axis horizontal) will correct the defect. The lowest concave cylindrical lens which gives the patient the best possible distant vision will be the correcting lens. This would be a case of Simple Myopic Astigmatism (As. M.). If the lens be — 2·5 Cyl., it would be As. M. 2·5 D; and for the optician we should write "— 2·5 D Cyl. Ax. Horiz."

The reader should now make a few experiments for himself with cylindrical lenses, by means of which he can produce artificial astigmatism in his own eye. Let him place Snellen's Sunrise figure opposite his eye at a distance of about 4 to 6 metres. If he now hold a + 1·0 Cyl. before his eye, with its axis horizontal, it gives a myopia of 1·0 D to the vertical meridian of the eye, while the horizontal meridian remains emmetropic; and consequently, he will see the central vertical line of the diagram distinctly, while the horizontal lines will be indistinct. By placing a — 1·0 Cyl. with its axis horizontal before the eye, in addition to the + 1·0 Cyl., the artificial astigmatism produced by the latter is corrected, and the whole diagram becomes distinct. Every other kind and degree of astigmatism can be similarly represented by lenses and similarly corrected.

* *Compound Astigmatism.*—If no line be very distinctly seen, then the examination may be commenced with Snellen's Distance Test-Types, and the patient tested in the ordinary way with spherical lenses until one be found which gives the best distant vision. This is placed in a spectacle-frame before the eye, and the meridians of greatest and least curvature of the cornea are ascertained, as explained already. If the spherical lens be + 4 D, and with it the horizontal lines in the Sunrise Diagram be the most distinct, then the vertical meridian is shown to be corrected, and the eye is probably still hypermetropic in the horizontal meridian, and requires a + cylindrical

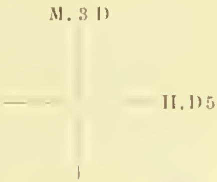


lens with its axis vertical, in addition to the spherical lens, to correct the entire defect. Suppose this cylindrical lens be found to be + 1 D. Cyl., then the H. in the horizontal meridian will be shown to be 5 D, and the astigmatism to be 1 D.

This will be noted as: "H. 4 D + As. H. 1 D Horiz."; or, as for the optician, "+ 4 D Sph. ⊃ + 1 D Cyl. Ax. Vert."[1] This is Compound Hypermetropic Astigmatism.

In an analogous way the examination is made for Compound Myopic Astigmatism, in which every meridian is myopic, but the vertical more so than the others.

* *Mixed Astigmatism.*—Lastly, cases are met with in which both concave and convex spherical lenses produce a certain amount of improvement, but neither give full vision. Placing, then, one or other before the eye in the spectacle-frame, the examination is proceeded with by aid of Snellen's Sunrise. The lowest concave spherical lens which will bring out one horizontal ray distinctly is ascertained. Let this be − 3 D; there is then myopia of 3 D in the vertical meridian. Now, having removed the − lens, the highest convex lens which will bring out one vertical line distinctly is ascertained. Let it be + 5 D; this indicates hypermetropia of that amount in the horizontal meridian. We may correct such a case in either of two ways: (*a*) by a Sph. − 3 D. which will correct the vertical meridian, but will increase the hypermetropia in the horizontal meridian by 3 D, making it 8 D, which can then be corrected by combining a cylindrical lens of + 8 D, axis vertical, with the above spherical lens; (*b*) by a spherical + 5 D, which will correct the horizontal meridian, but will increase the myopia in the vertical meridian to 8 D, necessitating the combination of a − Cyl. lens of that number with the + 5 D Sph. For reading, writing, etc., an over-correction



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[1] The sign ⊃ indicates "combined with."

of the horizontal meridian with + 8 D Cyl., thus rendering the eye myopic 3 D in every meridian, and enabling the patient to read at, or near, his far point, might be the most suitable arrangement.

As it is necessary, in order to test the degree, etc., of astigmatism accurately, that the accommodation be at rest, it is desirable, before the examination for any of the hypermetropic forms, to instil atropine into the eye.

* MEASUREMENT OF THE DEGREE OF ASTIGMATISM BY THE ASTIGMOMETER.—This is one of the most rapid and satisfactory methods of determining both the degree of astigmatism, and the position of the meridians of greatest and least refraction.

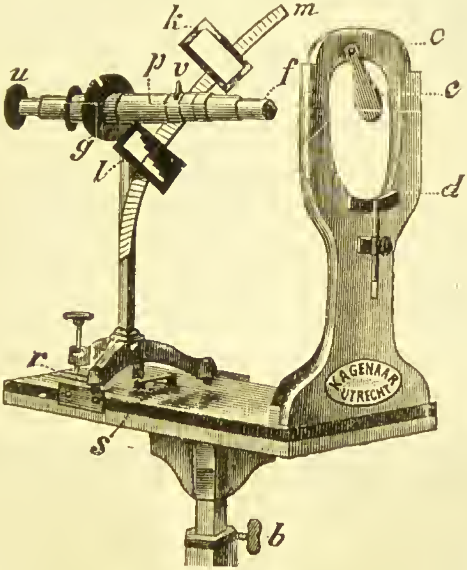

FIG. 64.—The Astigmometer.

The cornea reflects images of objects in the same manner s a convex mirror, and the smaller the radius of curvature he smaller will be the image of any given object. It is asy to calculate the radius of curvature of the cornea, if he size of the object, its distance from the cornea, and the size of the corneal image be known. The only difficulty lies in the measurement of this image; and it has been found that the best method of effecting this is to double the image by means of prisms, and then to alter the strength of the prism until the two images just come into contact. When this has taken place, a displacement equal to the size of the image has been produced. The amount of displacement, and hence the size of the image, can easily be calculated. This is the principle of the astigmometer (Fig. 64).

In order to measure the degree of astigmatism by it, we do not require to know the radius of curvature of the cornea, but merely to find out the difference in refractive power between the meridians of greatest and least curvature, and this the instrument enables us to do in a few seconds without any calculation.

It consists (Fig. 64) of a telescope (*p*) containing a double refracting prism between the object glasses, and two reflectors or mires (*k* and *l*), movable on an arc (*m*), which is fixed to the telescope tube. The latter turns on its own axis, and enables the arc to be placed in any meridian, its position being indicated on a graduated circle (*g*). The patient places his chin on the rest *d*, and looks into the tube at *f*, the eye which is not under observation being covered by the disc *e*. The surgeon then looks through the telescope at *u*, turns the arc *m* into a horizontal position, and observes the corneal images of the mires, which he gets into focus. He then moves the mires until the central images just come into

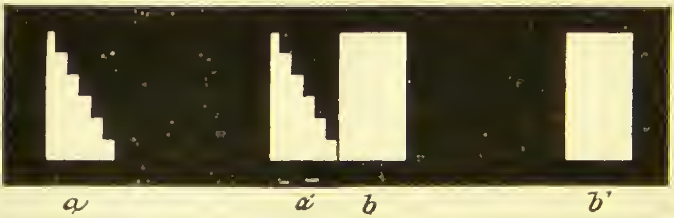

FIG. 65.

contact; the four images will then occupy the relative positions shown in Fig. 65. The arc is then rotated into the vertical meridian, and if the curvature of the cornea in this meridian be the same as in the horizontal meridian, the central images will still appear to be in contact; but if the radius of curvature in the vertical meridian be smaller, the intervals *a* to *b* and *a′* to *b′* will diminish, and consequently the central images will overlap, as in Fig. 66, each step of *a′* representing a difference of 1 Dioptre. So that in this case (Fig. 66) there would be an astigmatism of 2 D., and the greatest refraction would be in the vertical meridian.

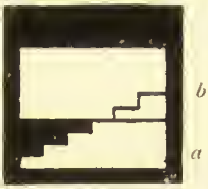

FIG. 66.

It is generally desirable to begin with the arc in the horizontal meridian. If the axes of the meridians of greatest and least curvature are oblique, then the images will not lie in one line, and the arc must be turned until they do so lie. An index which moves on the circle *g* (Fig. 64) gives the position of the axes. It will be seen from the above description that the astigmometer merely registers the amount of astigmatism, but does not enable us to estimate the general refraction of the eye. Moreover, it is the corneal astigmatism alone which is determined, and it will be found in most cases to differ only slightly from the total astigmatism. A useful modification in the mires consists in making them of complementary colours, for instance, one red and the other green,[1] the overlapping portion then appears white and is easily seen. Another great advantage which these coloured mires possess is the absence of dispersion, due to the use of mono-chromatic light, which renders the appreciation of the contact of the images much more delicate. We use the atter instrument at the Victoria Hospital, and find that it acilitates the observations considerably.

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[1] This instrument is made by Pfister and Streit, Berne

* *Lental Astigmatism.*—The astigmatism of the lens when at rest is supposed to be about 0·75 D, and contrary to the rule, and it tends therefore to correct or diminish corneal astigmatism with the rule. This assumption is based on the fact, that often, when there is no subjective astigmatism, the astigmometer shows a corneal astigmatism of 0·75 D with the rule, which the lental astigmatism must correct. The theory also accounts for the fact that the astigmometer over-estimates the total astigmatism by 0·5 D or 0·75 D when with the rule, and underestimates it by the same amount when against the rule, because in the latter instance the lental astigmatism must be added to that of the cornea, whereas in the former case, it must be deducted from it. This lental astigmatism may be caused by the shape of the lens, or by an obliquity in its position. A difference between the subjective or total astigmatism, and that of the cornea as measured by the astigmometer, can also be accounted for by the fact that the visual line does not pass through the centre of the pupil, and therefore the portion of the cornea measured by the astigmometer is not exactly the same as that which produced the retinal image. These discrepancies, however, do not detract materially from the practical value of the instrument.

Disturbances of vision due to astigmatism often make their appearance for the first time at middle age or even later, and are then apt to be mistaken for amblyopia. In such cases the cornea has been astigmatic all through life, but the defect has been masked by a compensating astigmatism of the crystalline lens, produced, it is supposed, by an unequal accommodative contraction of the ciliary muscle. When, as life advances, the amplitude of accommodation diminishes, the power of the ciliary muscle to produce this active compensatory lental astigmatism also diminishes, and finally disappears, and then the corneal astigmatism becomes manifest; or, in astigmatic individuals the astigmatism may alter in degree at this time of life. Under atropine, too, astigmatism may appear, the existence of which was not previously known. This is termed active, or dynamic, lental astigmatism.

Prescription of Cylindrical Lenses.—The position of the axis of a cylinder in a prescription is indicated by a line at the extremity of which a number indicates in degrees its inclination to the vertical or horizontal, as 2 D. Cyl. ax. $/^{30^\circ}$. Since the axis of cylindrical lenses must occupy a definite and unalterable position before the eyes, spectacle frames or rigid spiral-spring pince-nez should be ordered, and not folders. When first worn, cylindrical glasses frequently appear to cause distortion in the shape of objects, and unpleasant sensations of giddiness; these, however, disappear with a little perseverance in the use of the glasses.

IRREGULAR ASTIGMATISM.

In irregular astigmatism, the refraction of the eye differs not only in different meridians of the eye, but even in different parts of one and the same meridian. It is frequently due to irregularities in the surface of the cornea, the result of former ulcers, and also sometimes to irregular refracting power in different parts of the crystalline lens. It cannot be corrected. Its presence can be detected by a distortion and irregular movement of the disc when the lens is moved during the indirect method of examining with the ophthalmoscope, and also by an irregular shadow in retinoscopy. In some cases, there is a certain amount of regular astigmatism combined with it, correction of which may improve the vision.

* ANISOMETROPIA.[1]

By this term is meant a difference in the refraction of he two eyes, one being myopic, hypermetropic, or astigmatic, while the other is emmetropic, or ametropic in a way different from its fellow. So long as the difference in refraction is but slight (say 1 D or 1·5 D), it is generally possible to give the correcting glass to each eye. When the difference is considerable it is often impossible to fully correct each eye, because, binocular vision having never really existed, the patients are unable to tolerate the presence of a clear image on each retina. We must then be content with correction of the least ametropic eye, or of that one which has the best vision; or, we may partially correct the most ametropic, and fully correct the least ametropic eye. Each such case must be dealt with as it permits.

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[1] ἀ, *priv.;* ἴσος, *like;* μέτρον, *a measure.*

ANOMALIES OF ACCOMMODATION.

PRESBYOPIA.

This is a diminution in the amplitude of accommodation, which commences at an early age, and is due to natural changes taking place slowly in the crystalline lens. It might not therefore, strictly speaking, be considered as an anomaly. The power of accommodation commences to diminish in early childhood, the near point beginning then to recede from the eye. The accompanying diagram of Donders (Fig. 67), illustrates the decrease from the tenth year of age, and indicates the amplitude of accommodation at different ages.

The numbers along the upper horizontal line refer to the ages, those along the left-hand perpendicular line to the dioptres. The curve *r r* shows the refraction of the eye when in a state of rest. This is unchanged until the fifty-fifth year, when it begins to diminish; the emmetropic eye then becoming hypermetropic, the hypermetropic eye more hypermetropic, and the myopic eye less myopic. The curve *p p* shows the positive refracting power of the eye, corresponding to the punctum proximum, and its gradual diminution as life advances, and how at the age of 65 it becomes even less than the minimum refraction in former years. The two curves meet at the age of 73, and then all power of accommodation ceases. The number of dioptres included between the two curves on the vertical line corresponding to any given age

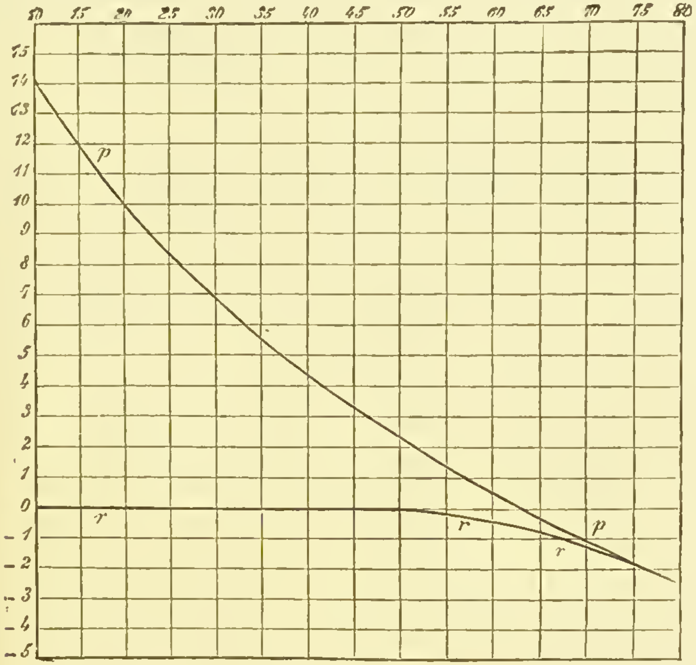

FIG. 67.

represent the amplitude of accommodation at that age—*e.g.*, at 30 years of age the amplitude is 7 D; at 50 years it is only 2·5 D. The amplitude of accommodation is the same at the same age in all forms of ametropia, as well as in emmetropia.

The cause of presbyopia lies chiefly in a progressive change n the crystalline lens, which becomes less elastic and more homogeneous in its different layers, and refracts light less strongly than before. In more advanced life, diminished energy of the ciliary muscle probably becomes a second factor in the production of presbyopia.

The near point gradually recedes from the eye until it reaches a distance beyond that at which the person usually reads, writes, sews, etc. Employments of this kind then become difficult, because the retinal images are too small to be clearly discerned, owing to the increased distance at which the work must be held from the eye; and, in order to make up for this smallness of the images, the individual is often seen to improve their brilliancy by procuring stronger light.

Presbyopia was defined by Donders to be present when the near point lies at more than 22 cm. from the eye, and we correct it by giving such a convex glass for reading, etc., as will bring the near point back to 22 cm. Now in order to see at that distance a positive refracting power (p) of $(\frac{100}{22} =)$ 4·5 D is necessary, and if the eye have not so much positive refraction, a convex glass must be given to it of such power as will bring p up to 4·5 D; and this lens is the measure of the presbyopia. At the age of 40 (*vide* Donders' diagram, Fig. 67) the eye possesses a positive refraction of just 4·5 D; and therefore from this age presbyopia (πρέσβυς, an old man; ὤψ) is said to commence in emmetropic eyes. The presbyopia, then, is equal to the difference between the positive refracting power possessed by the eye and 4·5 D, and the number thus found is the correcting glass for the presbyopia. The distance of 22 cm. is rather close to the eyes for the comfort of most people, and 33 cm. is more commonly taken as the reading distance. Presbyopia on the latter assumption is postponed for two or three years.

The glass required in presbyopia must also depend on the nature of the patient's work, which, of course, may require to be placed at some definite distance. This distance, the refraction of the eye, and the amplitude of accommodation (age of the patient), will determine the number of the glass which must be prescribed in each case.

It is important that in prescribing glasses for presbyopia, if there be any hypermetropic astigmatism present, it should be corrected by the suitable + cylinder lens added to the spherical glasses. It is also important that the glasses should be carefully centred for the reading distance—*i.e.*, that the visual lines, when they are converged to the distance at which the work is held, should pass through the optical centres of the glasses. The glasses must therefore be closer together, and also tilted forwards at the top, so that they may be at right angles to the visual axes. Moreover, if there be any insufficiency of the internal recti, it will be for the patient's comfort to decentre the lenses slightly inwards.

The following table indicates the presbyopia of the emmetropic eye :—

Age.	*p.* required.	*p.* existing.	Presbyopia.
40	4·5	4·5	0
45	4·5	3·5	1·0
50	4·5	2·5	2·0
55	4·5	1·5	3·0
60	4·5	0·5	4·0
65	4·5	0·25	4·25
70	4·5	–1·0	5·5
75	4·5	–1.75	6·25
80	4·5	–2·5	7·0

It is hardly necessary to point out that presbyopia comes n at a much earlier age in hypermetropes than in emmetropes ; while in myopes its advent is postponed ; or, in the higher legrees of myopia, it may not come on at all. The hypernetrope of 3 D would be presbyopic at the age of 27 ; because, n order to arrive at the 4·5 D of positive refraction required, e must have an amplitude of accommodation of (3 D + 4·5 D) ·5 D, and this he has only up to that age (*vide* Fig. 67).

The myope of 4·5 D can get along until something over 60 years of age without any glass for reading (*vide* above table). At 65, if he were emmetropic, he would have presbyopia of 4·25; consequently he will now require a + glass of only 0·25 D.

Presbyopia must not be mistaken for slight paralysis of accommodation. They are distinguished by the fact that in the former the amplitude of accommodation corresponds to the age of the patient as given in Donders' table, and the difficulty of near vision comes on gradually.

When presbyopia is associated with ametropia, which requires correction for distance, *bifocal lenses* are very convenient. A thin, oval or circular, lens representing the addition required for near vision is cemented on to the lower part of the distance glass, or is inserted between the two portions of which this is formed.

PARALYSIS OF ACCOMMODATION (CYCLOPLEGIA).

This may be partial or complete, and one or both eyes may be affected. It is usually combined with paralysis of the sphincter iridis (mydriasis), and the condition is then called ophthalmoplegia interna; but it is also seen without paralysis of the sphincter, and either alone or with paralysis of some of the orbital muscles supplied by the third pair, which also supplies the ciliary muscle—rarely with paralysis of the external rectus.

The Symptoms are similar to those of presbyopia, but come on rather suddenly. They give inconvenience to the patient according to the state of his refraction. If he be emmetropic, his distant vision continues good, while his vision for near work is much impeded. If he be hypermetropic, as he requires his accommodation for distant objects, vision for distance is interfered with, and still more so, vision for near objects. If he be myopic, vision is less affected than in either of the other forms of refraction; indeed, if he have more than 4 D of M, being able to see near objects at his far point, he may suffer little or no inconvenience.

Micropsia is a common symptom in cases of partial paralysis of accommodation, and is due to the fact that, while the retinal image is unaltered in size, the great effort of the defective accommodation gives the sensation of the object being much nearer to the eye than it really is.

Causes.—Paralysis of accommodation may be caused by poisons acting locally (atropine) or through the system (ptomaines, nicotine, lead); but it is also the result of, or is attendant upon, various diseases. It is one of the symptoms of paralysis of the third nerve; it may be due to rheumatism or to exposure to cold; or it may depend upon syphilis, syphilitic periostitis at the sphenoidal fissure, syphilitic gumma, or syphilitic inflammation of the nerve itself.

Double paralysis of accommodation is often nuclear. Paralysis of accommodation and mydriasis are sometimes forerunners by many years of serious mental derangement.

Diphtheria is a frequent cause of paralysis of accommodation, usually without, but sometimes with, mydriasis. The onset occurs most commonly some weeks after the throat affection, which need not have been of a severe character. Indeed, the faucial attack may have had no apparent diphtheritic character, and may have been so slight as almost to have escaped the notice of the patient, although sometimes albumen will be found in the urine. The lesion in these cases is probably a nuclear one, and the evidence points to miliary extravasations of blood in the floor of the fourth ventricle; but some hold that the paralysis is due to a poison, that it is a toxic paralysis.

In influenza paralysis of accommodation is seen, occurring sometimes in the acute stage and sometimes during convalescence. One recorded case went on to bulbar paralysis, and ended fatally; but complete recovery is usual.

Paralysis of accommodation in middle life may be due to diabetes, and should raise the suspicion of the presence of this disease. It may also occur in diseases of the spinal cord, *e.g.*, locomotor ataxy.

Blows on the eye are apt to cause paralysis of accommodation, usually with mydriasis.

The Treatment depends, of course, upon the cause of the paralysis. The instillation of a 1 per cent. solution of sulphate of eserine or of muriate of pilocarpine may be employed in all cases, and will at least produce temporary improvement of sight; but it can hardly be said to assist in the cure, except perhaps in slight diphtherial cases. Iodide of potassium and mercury are indicated in syphilitic cases, and iodide of potassium and salicylate of sodium in rheumatic cases. The prognosis in these cases must be very guarded, as it often happens that recovery does not take place. No further symptoms may occur, but in some instances it may be followed by external ophthalmoplegia. Where cure does not result the patient may be enabled to make better use of his eye or eyes by means of a convex glass or spectacles; but in this matter each case must be dealt with for itself—no general rule can be laid down.

In diphtherial cases a general tonic treatment, especially iron, is indicated; and here the prognosis is invariably favourable.

ACCOMMODATIVE ASTHENOPIA

has been already treated of under the head of Hypermetropia (p. 70).

SPASM OF ACCOMMODATION.

Spasm, or cramp, of accommodation in connection with hypermetropia and myopia has already been referred to. A few cases of acute spasm of accommodation have been reported. Occurring in an emmetropic or slightly hypermetropic eye, such a spasm produces apparent myopia. In some of the cases there was no assignable cause for the spasm, in some it was due to overwork, and in one to trauma of the cornea. The treatment is a lengthened course of atropine locally.

CHAPTER IV.

THE OPHTHALMOSCOPE.

Before proceeding to describe the ophthalmoscope, a brief statement of the properties of plane and concave reflecting surfaces (or mirrors) will be of use.

Laws of Reflection.—When a ray of light, O S (Fig. 68), meets a polished surface or mirror, M M, at a given point, S, the angle of incidence, *i*, formed with the perpendicular to the surface, P, is equal to the angle of reflection, *r*, and the incident and reflected rays O S, S R, lie with the perpendicular in one plane.

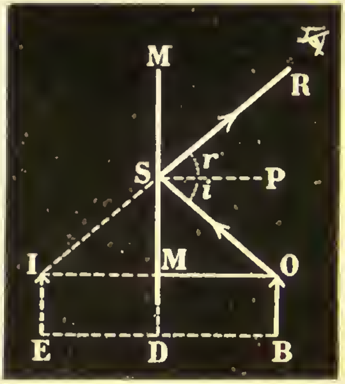

FIG. 68.—Reflection by a plane mirror.

Images formed by a Plane Mirror.—To an observer placed at R the point O would seem to be at I, where the prolongation of R S intersects the line I O perpendicular to the mirror, and O M is equal to M I. Similarly the image of the point B is found on the perpendicular B E, E D being equal to D B. The image I E therefore, formed by a plane mirror, is virtual, erect, and situated behind the mirror at the same distance from it as the object O B.

Images formed by a Concave Mirror.—In Fig. 69, *c* is the centre of curvature of the mirror M M. The rays *a*, *b*, parallel to the axis S*f*, meet the surface of the mirror at M and M′ and are reflected to F the principal focus. The angle of incidence *a* M *c* being equal to the angle of reflection F M *c*, the radius *c* M being perpendicular to the surface of the mirror at M. F lies midway between S and *c*; that is to say, the focal length of a concave mirror is equal to half the radius. Rays from a point *f*, beyond *c*, are made to converge at *f*′, between F and *c*, and the further away *f* is the nearer will *f*′ be to F; *f* and *f*′ are conjugate foci. The conjugate focus of a point nearer the mirror than F would be virtual, because the rays then diverge after reflection.

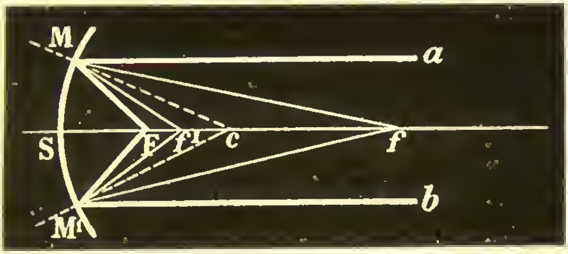

Fig. 69.—Reflection by a concave mirror.

In ophthalmoscopic work the source of light is usually further away than the centre of curvature of the mirror, and Fig. 70 shows how, in this case, a real inverted and diminished image of the light is formed. The image of the point O is found at I, the point of ntersection of the ray O I, which passes through the centre of curvature , without deviation, and the ray O S parallel to the axis, which passes rough the principal focus F, after reflection ; the image of the point is found in a similar manner. As O B approaches C, I M also pproaches it, and increases in size until at C object and image are equal size and coincide. When the object lies between F and the

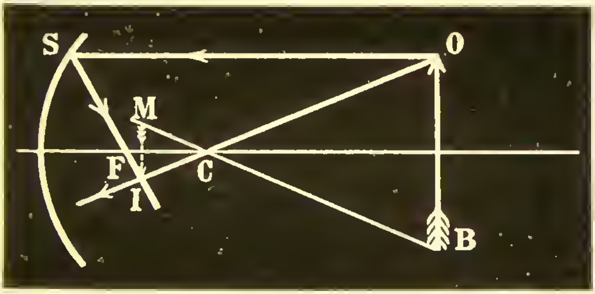

Fig. 70.—Image formed by a concave mirror when the object is beyond the centre of curvature.

mirror a virtual, erect, magnified image is seen. A concave mirror therefore resembles a convex lens in its action (chap. i., §§22 and 23).

To distinguish a Plane from a Concave Mirror the student should stand with his back to the source of light and, with the ophthalmoscope held in front of him and a little to one side, should throw the light reflected from it into his own eye; he will then see an erect image, if the mirror be plane, or an inverted image, if the mirror be concave. A simpler method consists in facing the source of light, and throwing the reflected light on a screen, say the palm of the hand, and moving the mirror towards or away from it; then, if the mirror be plane, a round image with a dark central spot will be formed at all distances; but, if the mirror be concave, at a certain distance an inverted image of the source of light will be formed.

Effect of Displacement of the Image with the Rotation of the Mirror round an Axis lying in the Plane of the Mirror.—When a *plane mirror* is rotated, the image of the source of light moves in a direction opposite to that in which the mirror is rotated. In Fig. 71 when the mirror is rotated from M_1 to M_2 the image of the light, L, will be found on the perpendiculars to the mirror, M_1 and M_2, at I_1 and I_2. The cones of rays emerging from these images, a_1 a_1 and b_2 b_2, will move with the rotation of the mirror as indicated by arrow B, while the images have moved in the opposite direction, shown by arrow A. When a *concave mirror* is rotated, the image moves in the same direction as the mirror.

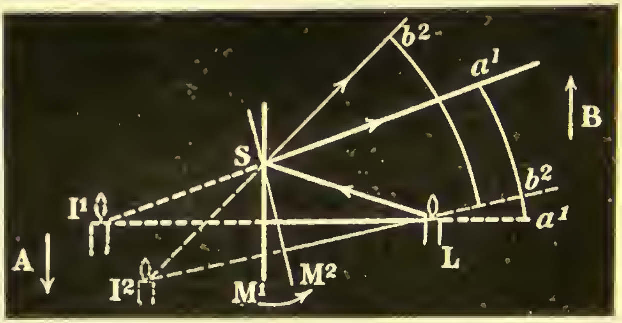

FIG. 71.—Motion of the virtual image in rotation of a plane mirror.

In Fig. 72 when the mirror is in the position M^1, the image of L is formed at I^1, on the secondary axis passing through the centre of curvature C^1; and, on rotating the mirror into the position M^2, the corresponding image will be found on the secondary axis L C^2, say at I^2, the change of position of the image being in the direction of the arrow, and with the movement of the mirror.

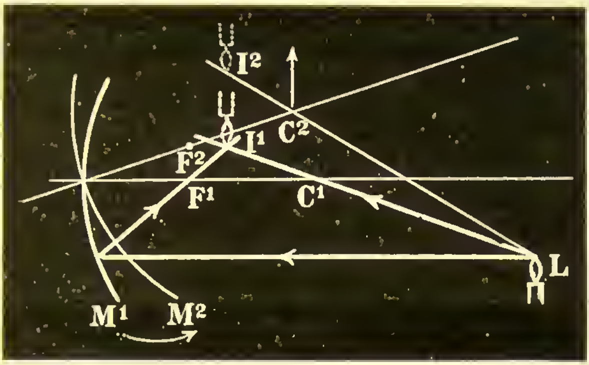

FIG. 72.—Motion of inverted image in rotation of a concave mirror.

The Ophthalmoscope.—Although the dioptric media of an eye may be perfectly clear and normal, yet no detail of its fundus can be discerned by the unaided eye of an observer who looks through the pupil, the latter being for him merely a dark opening. The reason of this is, that light can only enter the eye through the pupil and the refractive media. In albinos the pupil appears red, because the absence of the uveal pigment allows the light to penetrate the sclerotic and illumine all the interior of the eye in a diffuse manner. To explain :—Suppose the inside of a small box (*vide* Fig. 73) to be blackened, and on its floor some printed letters fastened, and a hole cut in the lid, which is then replaced—it will be found that, by aid of a lighted candle and with a little experimentation, the letters may be read through the aperture. The rays passing from the light (*L*) into the box through the aperture lluminate the opposite surface, and from this surface the rays *a*, *b*, and others pass out again through the opening, and some of them fall into the observer's eye at *E*.

But if, in order to make this box represent an eye, we place a convex lens, *n*, of the proper strength, immediately within the aperture, all the rays passing into the box (Fig. 74) from *L* are brought to a focus on its opposite side at *m* by the convex lens *n*, and, according to the law of conjugate foci, (chap i. § 16), all the rays passing out from the box meet again at the source of light (*L*), and hence none of them can be received by the eye (*a*) of the observer; nor can this eye be placed in any position where it could receive any of these rays, for if it be placed anywhere between the aperture and *L*, it would cut off the light passing from *L* into the box.

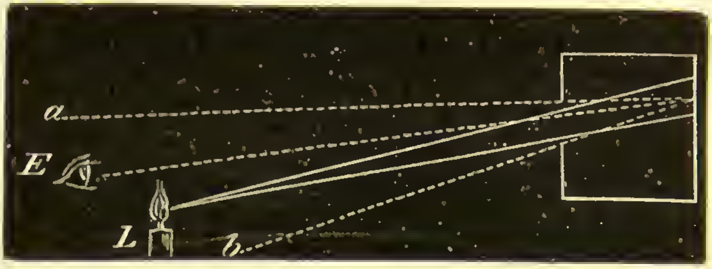

FIG. 73.

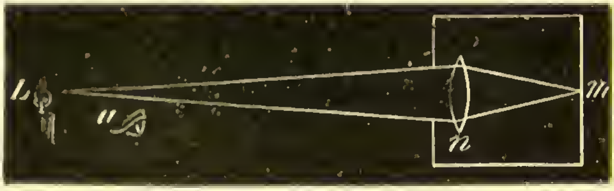

FIG. 74.

If the back of the box were further forward, the light would not be focussed on it, and the emergent rays would form parallel or conical divergent beams passing back to, and surrounding *L*. In the latter case, if an observer held his eye close beside the light, some of the divergent rays would enter it, and the letters would be visible. This explains the red pupil often seen in hypermetropia and aphakia.

Helmholtz's Ophthalmoscope.—If the eye of the observer could itself be made the source of light, the difficulty would be solved; and, practically, this is what Helmholtz accomplished with his ophthalmoscope in the year 1851. The instrument he invented was composed of a number of small plates of glass (*O*, Fig. 75), from which light from *L* was reflected into the

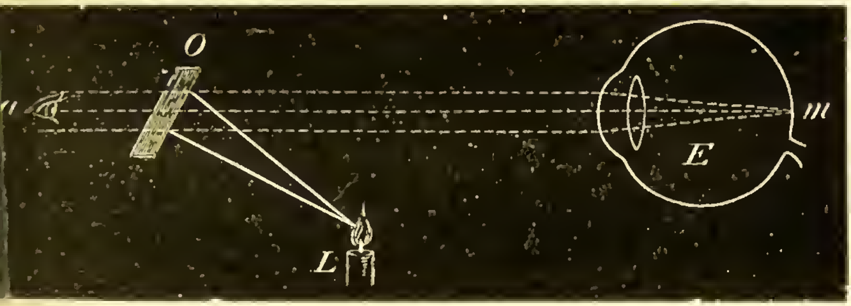

FIG. 75.

eye (*E*), and thus the fundus of the latter illuminated. From *n* rays pass back again by the same path to the ophthalmo-cope, some being reflected back to *L*; but some, passing hrough the ophthalmoscope, and falling into the observer's ye placed close behind the instrument at *a*, form in it an mage of *m*.

Modern Ophthalmoscope.—For the original ophthalmoscope f Helmholtz a concave mirror of 20 cm. focal length with central opening has been substituted. This mirror (*O*, ig. 76) throws convergent rays into the eye (*E*); and these, eing made more convergent by the refracting media, cross in ie vitreous humour, and light up part (*a b*) of the fundus. rom every point of this illuminated surface rays are flected back again out of the eye. If the latter be emmetropic, the rays from any one point become parallel on leaving it; and some of these parallel rays, passing through the aperture (*c*) of the ophthalmoscope, fall into the observer's eye, and, if it be emmetropic, are brought to a focus on its retina; the rays from m at m', those from x at x', and those from y at y'—and thus an image of the part $x\ m\ y$ is formed on the observer's retina.

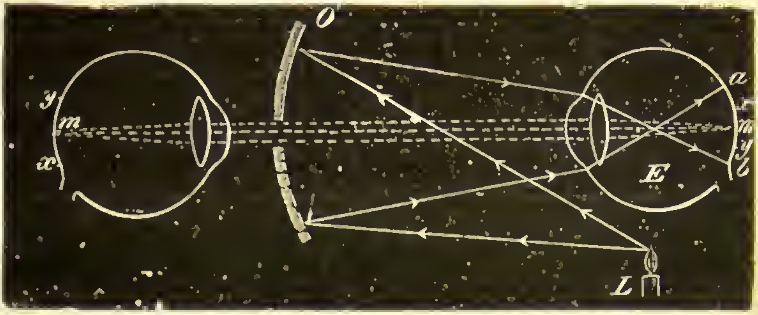

FIG. 76.

The foregoing method of examining with the ophthalmoscope is called the **Direct Method,** or the **Examination of the Upright Image.** The light should be placed on the same side as the eye to be examined, it should be on a level with the eye, and sufficiently behind the patient to leave the eye in the shade. The observer uses his left eye for the patient's left eye, and his right for the patient's right eye, and by a slight inclination of his head he can get very close to the patient's eye without coming into contact with his face. By this method the various parts of the fundus are seen in their natural positions, but much enlarged. The magnification is about 15 diameters in Em., more in M. and less in H.; and it is consequently very valuable for examining minute details. The area visible at one moment is, however, small, not much larger than the optic disc.

It is necessary that the observer should approach his eye as close as he can to the eye under examination, in order to receive as much of the light coming out of it as possible, and also to obtain the largest possible field.

Also the accommodation both of the observer's and of the patient's eye must be at rest, as otherwise the rays coming from the latter cannot form an image on the retina of the former, at least if both be emmetropic. If the patient exert his accommodation, the rays will, on leaving his eye, become convergent instead of parallel, and, falling into the observer's eye, will be brought to a focus in front of his retina. The same will happen if the observer exert his accommodation, and still more so if both patient and observer accommodate. The patient's accommodation can be relaxed by making him gaze at the black wall behind the observer's head, or his accommodation may be paralysed with atropine. But atropine should never be used in adults unless absolutely necessary, owing to the inconvenience it causes the patient.

Voluntary relaxation of the accommodation on the part of the observer is often a matter of much difficulty to beginners. With parallel optic axes our accommodation is relaxed; therefore, when we want to relax our accommodation, we produce parallelism of our optic axes. This sounds easy enough; yet, when the beginner approaches his eye close up to that of his patient, the knowledge that he is so close o the object he wishes to see renders the accomplishment f this parallelism and relaxation of accommodation very lifficult to many.

It can only be attained by practice, but it is assisted by he fact that the eye which is not in use gazes at the black vall behind the patient's head.

The **Indirect Method**, or the **Examination of the nverted Image,** is employed in order to obtain a more eneral view of the fundus than the direct method admits of. In addition to the ophthalmoscope, a convex glass—the object ns—(*l*, Fig. 77) of about 14 D is here used. The latter is held at about its focal length from the eye (E) under examination, while the observer throws the light from the mirror through it into the eye. In passing through l the rays are made convergent, and this convergence is increased by the refracting media, so that the rays cross in the vitreous humour, and light up a portion of the fundus oculi. From any points (a and b) of this illuminated place pencils of rays pass out

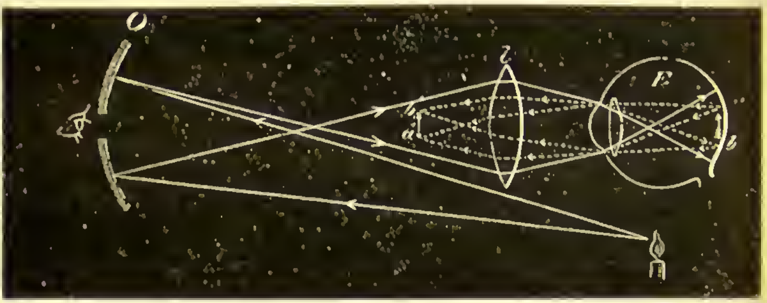

FIG. 77.

again from the eye, and, becoming parallel, pass through l and are united by it at a' b'; and thus a real inverted image, magnified about 4 diameters, is formed of the part a b, which image may be seen by the observer whose eye is placed behind O. The stronger the object lens (l) the more convergent will the rays from the examined eye be made; and consequently the closer must $a'b'$ be to each other, and the smaller and brighter must be the image formed. The weaker the object lens the larger and less brilliant is the image, and the less annoying to the observer are the reflexes from its surfaces.

If the lens be held at its focal length from the cornea, and then withdrawn until its principal focus is further from the eye than the anterior focus of the latter, the image will remain unaltered in size in Em., will increase in size in M., and diminish in H.

In examining by the indirect method, the observer first places the upper edge of the ophthalmoscope to his right supra-orbital margin, and, taking care that he is looking through the central opening of the mirror, he reflects the ight of the lamp into the patient's eye at a distance of about 50 cm. A red glare from the fundus will then be seen in the pupil. Keeping the pupil illuminated, the convex lens of 14 D, held between the forefinger and thumb of the observer's left hand, is brought up in front of the patient's eye, and kept there in the perpendicular position, the observer steadying this hand with the tip of the little finger on the patient's forehead. The object lens is now removed just far enough from the patient's eye to cause the margin of the pupil to disappear out of the observer's field of vision. The observer then ceases

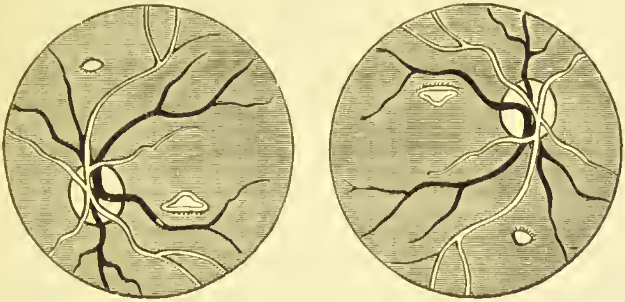

FIG. 78.

o look into the eye, and fixes his gaze on the object lens hen the inverted image of the fundus should at once become isible, if the observer accommodates for the proper distance —and will seem to be situated in the object lens, although t really is in the air somewhat this side of the lens.

If, as is usually the case, the ophthalmoscope be held in he right hand, it is better to place the light on the patient's eft, whichever eye be examined, as the observer's left arm ill not then interfere with the light when the lens is eld up before the patient's eye.

The diagram (Fig. 78) serves to illustrate the effect of nversion of the image. The left eye is seen in the upright nage at *a*, while the same eye is seen in the inverted image at *b*. In the diagram the two images are of the same size for the sake of convenience; although, of course, in reality the upright image is much larger than the inverted image. Moreover, it should not be supposed that nearly the whole fundus oculi, as here represented, can be taken in at one view with the ophthalmoscope. The portion visible with the ophthalmoscope at one moment, even in the inverted image, is small; so that it is necessary to examine the different regions in detail, in order to become acquainted with the condition of the whole of the fundus.

The reflex from the surface of the cornea gives a good deal of annoyance to every beginner. It cannot be done away with; but, as it moves in the opposite direction to a motion of the object lens, it is possible to see past it. The reflections from the convex object-lens are also extremely annoying, but may be removed to a great extent from the line of sight by a slight rotation of the lens on its axis. If a very high object lens (say + 20 D) be used, the reflections from it are more disturbing than from a lower number (say + 14 D).

To examine the *Optic Nerve* (or Optic Disc) the observer sits in front of the patient, and directs him to turn his eye somewhat to the nasal side, and slightly upwards; because the papilla, or disc, is situated about 15° to the inner side of the posterior pole of the eye, and about 3° above it. For instance, if the left eye be examined the patient is to direct his gaze, (without turning his head,) to his right and a little upwards, say towards the observer's left ear. It is well always to seek out the optic papilla in the first instance, not only because it is such an important part of the fundus oculi, but also because, examining from it towards the periphery, we are the better able to determine the locality of any pathological alteration.

Should the patient not direct his gaze in such a way as to enable the observer to see the optic disc or other desired region, it may be brought into view either by a motion of the observer's head in the opposite direction, or by a motion of the convex lens in the same direction, or by a combination of these measures. When the disc is opposite the observer's eye, the pupillary reflex is seen to become paler or even white, and the corneal image of the light will occupy the junction of the middle and outer thirds of the horizontal diameter of the cornea.

The *Macula Lutea* should then be examined. It may be seen by directing the patient to look straight at the hole of the ophthalmoscopic mirror, for it will then correspond with the macula lutea of the observer's eye. It is more readily seen in the inverted than in the upright image; but its examination is often very difficult, owing to contraction of the pupil produced by the strong light falling on so sensitive a portion of the retina, and by the reflections from the surfaces of the cornea and crystalline lens, which fill the area of this contracted pupil. It is therefore a better plan to direct the patient to look somewhat to the side of the eye under examination—*e.g.*, to the right side of the observer's forehead, if the left eye be under examination, and then by motions of the convex lens to bring the macula lutea into view.

After this the *Periphery of the Fundus* in every direction is to be examined by making the patient look upwards, downwards, to the right, to the left, etc.

The indirect method possesses the following advantages:—It gives a large field in which it is possible to rapidly locate the position of a lesion, it can be used no matter what the error of refraction may be, and it is not necessary to approach close to the patient's face.

ESTIMATION OF THE REFRACTION BY AID OF THE OPHTHALMOSCOPE.

Estimation of the Refraction by the Inverted Method.—The position f the inverted image, in other words its distance from the lens used, epends on the strength of the lens, its distance from the eye, and on the refraction of the eye. If the number of the lens and its distance be fixed, the refraction alone causes the alteration in the position of the inverted image. In Em., the emerging rays being parallel, the image is formed at the focus of the lens; in M., the rays being convergent, the image is closer to the lens; and in H. it is further away, owing to the divergence of the rays coming out of the eye. The methods of measuring the refraction which are based on these principles have not, however, come into general practical use.

By the Direct Method at a distance of about 50 cm. from the observed eye into which light from the ophthalmoscope mirror is thrown, the observer will be able to make the *qualitative* diagnosis of the refraction. If he can see some of the details of the fundus, the eye is either myopic or hypermetropic; but if it be emmetropic, or have M. of less than 2 D, he will be unable to see any detail. The explanation of this is that, in myopia, the rays coming out of the eye form an inverted image at the far point of the eye in the air, and this image can be seen by the observer who accommodates his eye for that point. In hypermetropia, the rays coming out divergently from the eye pass into the observer's eye, and, by an effort of accommodation on his part, he will see an upright image of the portion of the patient's fundus oculi from which they come. But in emmetropia, or low M., inasmuch as the rays come out either parallel or very slightly convergent, those from any two points (*m*, *n*, Fig. 79) at a short distance

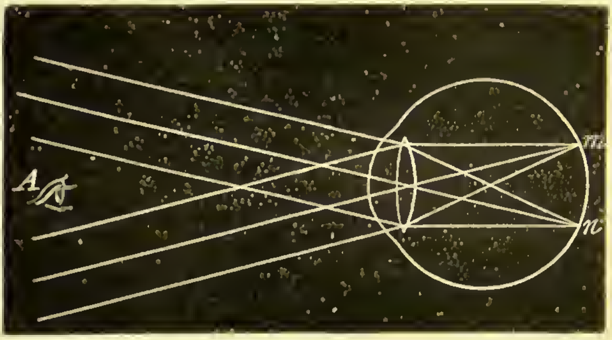

FIG. 79.

from each other in the fundus on emerging from the eye diverge quickly from each other, and the observer a little way off (at *A*) receives none of them into his eyes, or obtains only an indistinct image or red glare. If he go very close to the eye he can see details.

If, on the observer moving his head from side to side, the vessels, etc., of the observed fundus move with him, the case is one of hypermetropia, if against him it is a case of myopia. In H. (Fig. 80) the observer at O sees an erect image of the fundus at F behind the plane of the pupil, P, and it appears to be situated at A; on moving the head to O′, the line of vision is O F, and F appears to be at A′. In myopia (Fig. 81) the image is an inverted one lying in front of the plane of the pupil at F, and when the observer changes to O′ the image appears to be in the pupil at A′.

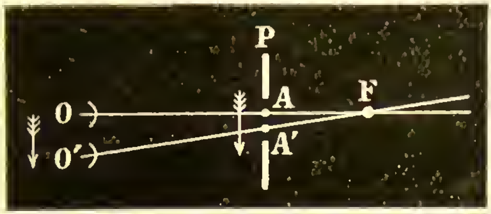

FIG. 80.—Apparent motion of fundus with the observer in H.

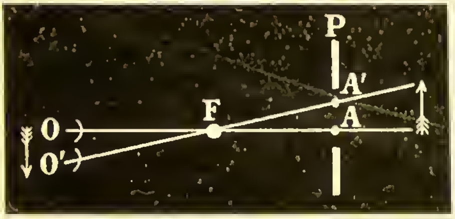

FIG. 81.—Apparent motion of fundus against the observer in M.

*For the *quantitative* determination of ametropia a refraction ophthalmoscope is required. This instrument is provided with a number of convex and concave lenses capable of being brought into position behind the sight-hole in rapid succession by a simple mechanism; and also with a tilted mirror which avoids the necessity of holding the ophthalmoscope in an oblique position, and thus the lenses are maintained in a position at right angles to the visual axis of the observer. The direct method, close up to the patient's eye, is employed.

It is necessary, in the first instance, that the observer be acquainted with the nature of his own refraction.

**If the Observer be Emmetropic* he can see the fundus oculi of an emmetrope in the upright image without any lens, provided he go close enough, as the parallel rays coming from the examined eye will be focussed on his retina, because his eye is adapted for parallel rays.

In order to see the fundus oculi of a hypermetrope without any effort of accommodation, he must place such a convex lens behind his ophthalmoscope as will render the divergent rays coming from the patient's eye parallel before they pass into his eye. This lens is the measure of the patient's hypermetropia, because it shows how many dioptres the eye wants of being emmetropic. The lens which makes the divergent rays coming from the patient's retina parallel, would also give to parallel rays passing into the eye such convergence that they would meet on the retina—*i.e.*, it would also correct the hypermetropia if the patient were examined with test-types and glasses (p. 65). (See Fig. 55.)

The emmetropic observer can of course see the fundus oculi of a hypermetrope by the direct method without the correcting glass, if he use his accommodation to overcome the divergence of the rays coming from the observed eye, and this is usually the case in the lower degrees of hypermetropia. The observer generally relaxes his accommodation according as he substitutes convex lenses for it, until he reaches the *strongest* lens with which he can distinctly see the fundus. This is the correcting lens.

To see the fundus oculi of a myope, the emmetropic observer must place a concave glass behind his ophthalmoscope, in order that the convergent rays coming from the observed eye may be made parallel before they pass into his eye; and the *lowest* concave lens which enables him to see the fundus oculi distinctly is the measure of the myopia (see p. 49), as showing by how many dioptres it is in excess of emmetropia.

The emmetropic observer cannot possibly see the fundus oculi of a myope without the correcting glass, as the rays are brought to a focus in front of his retina, and if he use his accommodation he merely makes them still more convergent. But, by means of an effort of his accommodation he can see the myopic fundus with a lens which over-corrects the myopia, and hence the importance of selecting the *weakest* concave glass with which the fundus is distinctly seen.

If the observer be ametropic, he may either correct his ametropia by wearing the suitable lens, and then proceed as though he were emmetropic, or else, and which is perhaps the better plan, he must allow for the amount of his ametropia.

For example:—

*The *Hypermetropic Observer* of say 3 D requires a + lens of 3 D in order to see an emmetropic fundus oculi, this lens going altogether to correct his own defect. If in order to examine the fundus of another eye he require a + lens of 6 D, the examined eye must be hypermetropic 3 D, the other 3 D going to correct the observer's H. If he be able to see the fundus oculi under observation without any lens, it shows that the eye has an excess of refraction corresponding to the want of refraction in his own eye—that is to say, it is myopic 3 D. If he require a concave 2 D, his want of refraction—his hypermetropia—is not enough by that number of dioptres, and he has to do with an eye which is myopic 5 D (3 D + 2 D). Again, if he can see the fundus distinctly with a + lens, say + 1·0, which is less than his own correcting glass, this shows that the eye he is examining is myopic, but myopic to a lesser degree—in this instance by 1 D—than he himself is hypermetropic, and the examined eye here would be M. 2·0 D (*i.e.*, 3·0 − 1·0).

If the Observer be myopic the same method of reasoning applies.

**The Existence and Degree of Astigmatism may be Determined with the Ophthalmoscope.*—We know that astigmatism is present, if in the upright image we see the upper and lower margins of the disc and the horizontal vessels well defined, while the lateral margins and the vertical vessels are blurred, or *vice versâ.* Again, we know that astigmatism is present if in comparing the shape of the optic disc in the upright and inverted images, we find it to be an oval with its long axis perpendicular in the former, and with its long axis horizontal in the latter, showing that the refracting media are more powerful in the vertical than in the horizontal meridian.

We may ascertain the kind and degree of astigmatism as follows:—

If in the upright image with relaxed accommodation, we can see the retinal vessels in one meridian distinctly, while in order to see those in the opposite meridian a concave or convex lens behind the ophthalmoscope is required, we know that the case is one of simple myopic or hypermetropic astigmatism; the emmetropic meridian being that at right angles to the vessels[1] seen without any lens, and the number of the lens indicating the amount of ametropia in the other meridian.

If, in the two principal meridians, two concave lenses or two convex lenses of different strength be required, we have to deal with a case of compound astigmatism, myopic or hypermetropic; the greatest error of refraction being in the meridian at right angles to that one, the vessels of which are made distinct by the strongest lens.

If a concave lens be required to bring into distinct view the vessels in one meridian, while a convex lens is required for the opposite meridian, the case is one of mixed astigmatism. Myopia exists in the meridian at right angles to that in which the vessels are brought into view by the concave lens, and hypermetropia exists in the opposite meridian.

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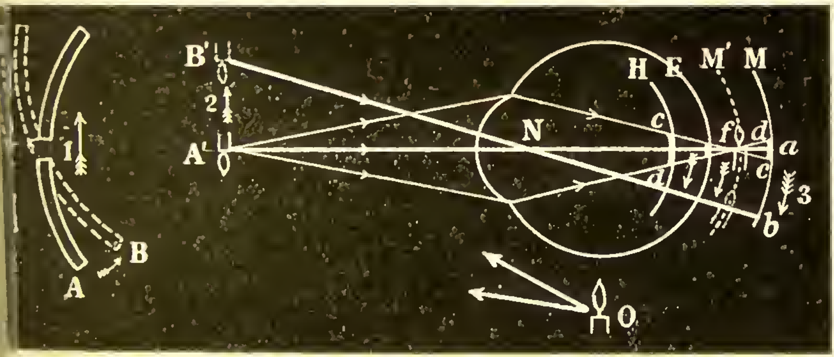
[1] The vessels may be regarded as lines, and the explanation given on pp. 74 and 75 applies to them also.

RETINOSCOPY.

Retinoscopy, or the Shadow Test, is the most useful method for determining the refraction by the ophthalmoscope. It consists in illuminating the eye with the plane or concave mirror at a distance of a little over a metre, or more, and then by moving the light into different positions by rotation of the mirror round an axis lying in its own plane, the observer noting on which side of the illuminated pupil the shadow appears, and in which direction it moves across he pupil.

Theory of Retinoscopy.—In the explanation which follows, the *con-*



IG. 82.—Retinoscopy with concave mirror. Shows that the real movement of the retinal image is the same in all conditions of refraction. 1. Motion of mirror, or of light area on patient's face. 2. Motion of aerial image produced by mirror (immediate source of light). 3. Real motion of retinal image of light.

ve mirror is supposed to be used. In Fig. 82, rays from the light, O, aced at the side of the patient's head, strike the mirror, A, which rms an inverted aerial image, A′, as explained at the beginning of this chapter. This image is now the immediate source of light, rays from which, entering the eye, are made to converge toward their conjugate focus, *f*, on the secondary axis, A N *f*, passing through the nodal point, N. If the retina be at M′, or in other words, if the eye be myopic, with its far point at A′, a distinct and bright image of the light, A will be formed on the retina at *f*. In any other condition of refraction such as emmetropia, E., hypermetropia, H., or any higher degree of myopia, M., a circle of diffusion, *c d*, is formed by each point of light, and a blurred image is the result; so that the area of illumination is less bright, and its boundary less defined. The further the retina is from *f*, the less will be the brightness and the definition of the margin of the illuminated area.

Now let the mirror be rotated from A to B, the movement of the light area, surrounding the eye, on the patient's face will, of course, take the same direction, indicated by the arrow 1. As explained at the beginning of this chapter, the immediate source of light will move to B′, shown by arrow 2, and its image will be formed, more or less distinctly, on the retina, at the point at which it is intersected by the secondary axis B N *b*. The retinal image, therefore, will move in the direction of arrow 3, from *a* to *b*, and this motion, as the figure shows, is the same in all positions of the retina. The real motion of the retinal image of the light in the observed eye is therefore independent of the refraction of the eye, and is in a direction contrary to that of the immediate source of light, and also against the motion of the concave mirror.

The observer cannot, however, see directly what is actually taking place on the retina of the observed eye, since he can only examine it through its refractive media. It remains, therefore, to determine the effect of the refraction of the observed eye on the motion as it appears to the observer; this may be called the apparent movement. What the observer sees is the image, real or virtual, formed by the observed eye, at its conjugate focus or punctum remotum, and therefore the apparent movement will depend on the position of the far point.

In H (Fig. 83) the immediate source of light, A, illuminates a portion of the retina at *a*. The rays *e*, *f* emerging from this point diverge, and entering the observer's eye seem to him to come from *α*, the far point of the hypermetropic eye. When, by reason of a rotation of the mirror to B, the light moves to B′, its retinal image *b*, seems to be at *β*. The illuminated area seems therefore to have moved in the direction of arrow 4; that is, *against* the motion of the mirror (arrow 1).

In Em. similarly, the emergent rays are parallel, and the image is projected by the observer to a position behind the eye under examination. Stated simply, in both cases an erect image of the fundus is seen, therefore no reversal of the rays takes place between the eye of the observer and that of the person under observation; and consequently, the apparent motion is the same as the real. As the light moves from *a* to *β* and so passes on, the pupil will first appear to become darkened above, and the shadow will move across it as shown in the circle P.

In Myopia, on the other hand (Fig. 84), the rays from the illuminated area *a* converge to form an inverted image at *α*, the far point of the

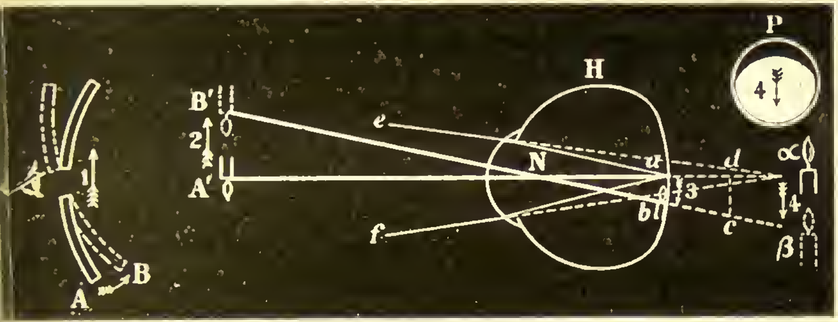


FIG. 83. Retinoscopy, with concave mirror, in hypermetropia. 1. Motion of mirror. 2. Motion of immediate source of light. 3. Real motion of retinal image. 4. Apparent motion of retinal image.

eye, situated on the secondary axis AN*a*. When the immediate source of light moves from A′ to B′, the apparent movement is from *α* to *β*.

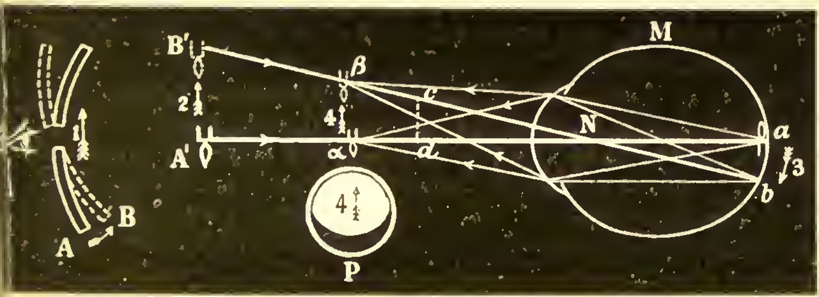


FIG. 84.—Retinoscopy with concave mirror in Myopia. Numbers as in Fig. 83.

this case a reversal of the relative position of the rays takes place, fore they enter the observer's eye; the upper rays become the lower d *vice versa*. Hence this is sometimes called the point of reversal. this case the darkness will appear first at the lower edge of the pil, and will travel upwards as indicated in the circle P, that is to y, in the same direction as arrow 1, *with* the movement of the ncave mirror.

The above explanation only holds good in myopia, when, as in the figure, the far point of the eye under observation lies in front of the observer's eye. If, however, the far point be situated further back than the observer's eye, the rays will not have met to form the inverted image, but will enter his eye retaining the relative positions which they bore to each other on emerging from the eye under observation; consequently the observer will see an erect image of the illuminated area, and the movement will be as in H. and Em., namely, against the concave mirror. It is obvious, that the lower the degree of myopia the further away the observer must be in order to see the reversal of the movement.

An error of refraction in the observer's eye does not influence the apparent movement, but merely renders the appearance more or less distinct to him. It should also be stated, that as the observer accommodates for the patient's pupil, and not for the far point of the retina of the patient, the image seen is always more or less diffuse.

Retinoscopy with the plane mirror.—The immediate source of light in the case of a plane mirror is a virtual upright image behind the mirror (Fig. 71). It moves in the opposite direction to the motion of the mirror, and not with it, as in the case of the concave mirror. Hence the real movement of the retinal image in the patient's eye will be with the mirror. The apparent movement will, therefore, be the same; that is, with the mirror, in Em., H., and in low M., where the point of reversal is further away than the observer. In higher degrees of M., with the point of reversal nearer than the observer, the real motion will be reversed, and hence the apparent motion will be *against* the motion of the mirror.

Degree of illumination, form, and rate of movement of the shadow.—As shown in Fig. 82, when the retina is at the conjugate focus of the immediate source of light, the illumination is at its greatest. The further away the retina is from the conjugate focus, that is to say, the higher the H. or M., the larger must be the area over which the light is spread, and therefore the more defective the illumination becomes, and the less defined and the fainter is the edge of the shadow.

The higher the error of refraction, the nearer to the eye is the far point, and the smaller is the remote image; but with the smaller image a larger field is obtained, and more of the circular edge of the shadow is seen; hence, the latter appears crescentic. In the lower degrees of ametropia and more especially in Em., the magnification is much greater and the field is smaller. Therefore, a small portion only of the large circular edge is visible, causing the shadow to appear less crescentic and more linear.

The apparent rate of movement depends more on the degree of magnification of the remote image, than on the real rate of movement of the retinal image. The less the magnification the slower the movement appears, for instance in Figs. 83 and 84, if the far point were in each case at c, the light would have to travel only from d to c, instead of from α to β, with the same rotation of the mirror. At c, therefore, it would appear to travel a shorter distance in the same time, and would therefore appear to move slower. The higher the ametropia, then, the slower appears to be the movement of the shadow.

Practice of Retinoscopy with the Concave Mirror.—The examination is conducted in the dark room. The light s placed at the side of, or above the patient's head, behind he level of his eye so that the latter may be in the hadow. If the concave mirror be used, the observer its at a distance of 1·25 m. in front of the patient. The cal length of the mirror should be about 22 cm., and e diameter of the sight hole about 3 mm. The observer ould correct any error in his refraction. The light is en thrown into the patient's eye, near the region of the acula lutea, but not on it, unless the pupil be dilated by ropine, otherwise the pupil becomes too small and the d reflex too faint. The observer accommodates for the pil, and rotating the ophthalmoscope, usually in the rizontal and vertical meridians, he observes the shadow the circumference of the pupil. When the mirror is ated—say, in the horizontal meridian—the edge of the dow will be vertical, it will move horizontally, that is right angles to its edge, and it will indicate the refraction the horizontal meridian. If the movement of the shadow with the movement of the mirror, or with the light on the ient's face, myopia is present; if it move *against* the ror, Em., H., or M. of less than 1 D is present.

The reason why the shadow is against the mirror in cases less than 1 D is that, in M. of 1 D, the inverted image point of reversal of the emerging rays, is situated at far point of the patient's eye, namely 1 m. in front of patient, and the observer being 25 cm. further away sees inverted image. But if the myopia be less than 1 D, far point, or point of reversal, lies behind the observer's head, and he now sees an erect image as in Em. or H., and the apparent movement is then the same as in Em. or H., namely against the mirror.

In order to estimate the error of refraction, a trial spectacle-frame is put on the patient's face. If the shadow move with the mirror, we know at once the eye is myopic. To find the degree of myopia the observer puts a low concave-glass (say – 1 D) into the frame; and if the shadow still move with the mirror, he puts in a higher number (say – 1·5 D), and so on until he comes to a glass which makes the image move against the mirror. If this be – 3 D, the myopia is 3 D. It might be supposed, as the shadow now moves against the mirror, that this glass over-corrects the myopia; but this is not so, because, as already explained, when the myopia is very low the image is formed close to the observer's eye, or behind his head, and he consequently gets a shadow moving against the mirror, although low myopia, and not emmetropia, is present. Consequently, – 0·5 D, or – 1 D, has to be added on to the lens, which gives the effect of no distinct shadow; or rather, by the above plan, it is not deducted from the lowest lens, which makes the shadow move against the mirror.

If the shadow move against the mirror, we have to determine whether the eye is emmetropic, hypermetropic, or slightly myopic. Should the illumination be bright, and the shadow well defined, the eye is emmetropic, or not far removed from it; and if the shadow be ill defined and crescentic, we may feel sure the eye is highly hypermetropic. We first put on + 1 D, and if the motion be still against the mirror, the case is one of hypermetropia, and higher numbers are at once proceeded to, until that one is reached which causes the shadow to move with the mirror. The measure of the hypermetropia is 1 D less than the glass so found, for it has evidently over-corrected the defect, having made the eye 1 D myopic.

If, however, on putting on + 1 D we find the shadow to move with the mirror, we change it for + 0·5 D; and if still the motion be with the mirror, the eye is, beyond doubt, slightly myopic, – 0·5 D or so. But if with + 1 D the shadow move with the mirror, while with + 0·5 it continue to move against it, the eye is emmetropic.

In *astigmatism*, the light being differently focussed in two meridians at right angles to each other, and being drawn out into a line or oval of diffusion, causes the illuminated area to appear like a band. The boundary of the shadow therefore is more of a straight line than a circle. If the axes of the astigmatism be oblique, the edge of the shadow will lie in one of the meridians and the movement will take place in the ther—according to the direction of he rotation of the mirror. Even if he mirror be not rotated in the irection of the meridian of greatest r least refraction, the edge of the hadow will nevertheless lie in the irection of one of these meridians, amely in that which is nearest to e axis of rotation, and will appear move in the meridian at right gles to it. This is due to an tical illusion explained by Fig. 85.

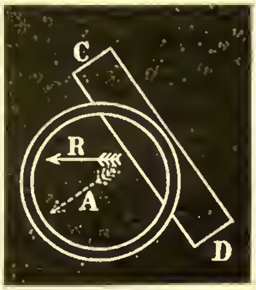


FIG. 85.—If C D be moved behind the circle in the direction of R, its obliquity being preserved, it will appear to a person who sees only the portion inside the circle, to move in direction A.

It may be found that in opposite meridians there is a fference in the motion of the shadow, and this indicates e presence of astigmatism. When the difference is one rely of rapidity of motion, or of intensity of illumination d shadow, it is either simple hypermetropic or compound igmatism. But if in the two meridians there be a differ- ce in the direction of the motion, then it is simple myopic mixed astigmatism.

In some rare cases the refraction is different at opposite sides of the pupil, and a double shadow is seen. These shadows move simultaneously in opposite directions; that is, towards or away from each other, like the blades of a scissors, and hence the condition is known as "scissors movement." In conical cornea, an irregular or triangular shadow is seen, with its apex near the centre of the pupil. It rotates round its apex with the movements of the mirror. In irregular astigmatism, the shadow appears broken up very irregularly, and different portions of it move in various directions.

The best method of ascertaining the degree of astigmatism and its correcting glass is to correct each of the principal meridians separately with spherical lenses. In compound astigmatism, the difference between the two lenses found indicates the degree of astigmatism, and also the cylindrical lens which, combined with the correcting spherical lens for the least ametropic meridian, is required to neutralise the defect. In mixed astigmatism, the addition of the two numbers gives the cylindrical lens, while one or other of them, usually the — D, is used as the spherical lens.

Retinoscopy with the plane mirror.—As explained on p. 96, the immediate source of light moves in a direction the reverse of that which is produced by the concave mirror; therefore, the apparent movement is *with* the mirror in H., Em., or low M., and *against* it in the other degrees of M. It will be noticed that this is the same as the apparent movement of the vessels when the observer moves his head (p. 107). The advantage of the plane mirror is, that the observer can stand further away from the patient, and thus diminish the error of observation. If, for example, the distance be a little more than 4 m. when the shadow moves with the mirror, the observer knows, if M. be present, it must be less than 0·25 D. He has still to decide whether this indicates E. or H. He does so by putting a low + lens (say + 0·25) before the patient's eye, and if then, standing at a distance of 4 metres, the motion be altered by this glass to one against the mirror, he knows that the eye has not a hypermetropia of 0·25 D, consequently that it is emmetropic. But if this lens does not at that distance cause a change in the motion of the shadow as originally obtained, the eye must be hypermetropic to at least the extent of 0·25 D; and, in order to ascertain how much more of H. than this may be present, it is now only necessary to continue increasing the strength of the lens in front of the patient's eye, until one is reached which, at 4 metres from the eye, produces the myopic motion. The observer knows that he has now slightly over-corrected the hypermetropia of the eye, and that the next lens lower is its measure.

A plane mirror of 4 cm. diameter, and of which the sight-hole is 4 mm. in diameter, is the pleasantest to use for retinoscopy.

Detection of Opacities in the Refractive Media by the Ophthalmoscope.—Opacities in the refractive media can be best detected with the ophthalmoscope by the direct method. All opacities look black in the red pupil, because they intercept the light returning from the illuminated fundus.

Two methods of examination are employed. In the first he eye is examined at a distance of about 30 cm.; and he patient is directed to move the eye in different directions, n order to bring any peripheral opacities into view and also o localise them. Movable opacities must lie in the fluid media. They are almost always in the vitreous humour, and an be seen to float to and fro when the eye comes to rest. Fixed opacities move with the eye, and lie in the cornea or lens, or sometimes in the vitreous. Fig. 86 illustrates the pparent displacement of an opacity in the pupil according o its position in the media. When the eye of the observer O s opposite the pupil, the opacities 1 to 4 lying on the axis appear as one point in the centre of the patient's pupil (shown by P). When the eye is rotated upwards, or the observer moves downwards, 2, which is on the anterior surface of the lens, in the plane of the pupil, will still appear to be in the same position, while 1, seen in the direction *a b*, will seem to be displaced upwards, and 3 and 4 downwards, the relative positions being as indicated in the circle at P′.

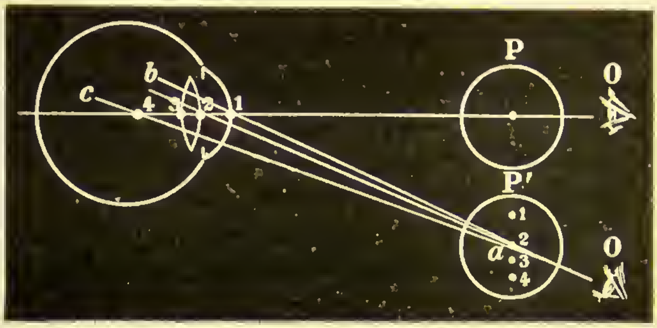


FIG. 86.—Apparent position in the pupil of opacities of the media when the observer alters his point of view.

The second and more delicate method of detecting opacities, consists in examining the eye close up with a convex lens of 20 D, behind the sight hole of the mirror. Very fine opacities can be seen in this way, such as very delicate punctate deposits on the cornea. Focussing for different levels can be accomplished by approaching closer for deeper opacities, or by using gradually weaker lenses. Too strong illumination interferes with the perception of faint opacities, hence the plane mirror serves better for this purpose than the concave.

THE NORMAL FUNDUS OCULI AS SEEN WITH THE OPHTHALMOSCOPE.

The Optic Papilla, or Optic Disc.—This is the first object to be sought for by the observer. It presents the appearance of a pale pink disc, somewhat oval in shape, its long axis being vertical. Occasionally the long axis lies horizontally, and sometimes the papilla is circular. The papilla is generally surrounded by a white ring, more or less complete, called the sclerotic ring, and often, outside this again, by a more or less complete black line, the chorioidal ring (Fig. 87). The sclerotic ring is due to the chorioidal margin not coming quite up to the margin of the papilla, the foramen in the chorioid for the passage of the optic nerve fibres being somewhat larger than that in the sclerotic, and consequently a narrow edging of the white sclerotic is exposed. The chorioidal ring is the result of a hyper-development of pigment at the margin of the chorioidal foramen. The complexion of the optic disc results from the pink hue derived from its fine capillary vessels, combined with the whiteness of the lamina cribrosa, and the bluish shade of the nerve fibres. It is frequently not equal all over, but s paler on the outer side, where he margin is more defined, and where the nerve fibres are often ewer than on the inner side. The apparent colour of the apilla depends also upon the complexion of the rest of the undus. If the latter be highly pigmented, the papilla appears ale in contrast; while, if there be but little pigment in the horioid, the papilla may appear very pink. The complexion every normal papilla is not identical, and care must be ken not to make the diagnosis "Hyperæmia of the papilla" here merely a high physiological complexion is present. The pper and lower margins of the papilla are often, especially in ung people, a little indistinct, and show a delicate striation the direct method of examination. This may be greatly

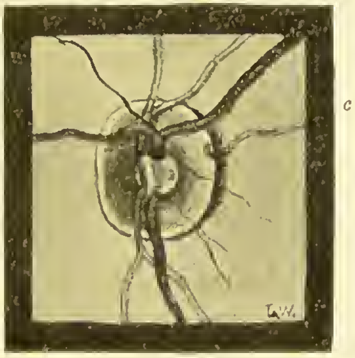


Fig. 87.—Normal optic disc, showing a physiological cup, scleral and chorioidal rings, and cilio-retinal vessel (c).

exaggerated in hypermetropes, and has in them been sometimes erroneously taken for optic neuritis.

A physiological excavation of the optic papilla is often met with (Fig. 87). It is either on the temporal side or in the centre of the papilla, and can be recognised from the parallax[1] which may be produced, and from the paleness of this portion of the papilla. When the excavation is very deep, one may sometimes observe the lamina cribrosa in the form of grey spots (the nerve fibres) surrounded by white lines (the fibrous tissue of the lamina).

A physiological excavation differs from a pathological excavation, in that it does not reach the margin of the papilla all round. It is caused by the crowding over of the nerve fibres to the inner side of the papilla. Yet sometimes, a healthy optic papilla will be met with, in which the excavation apparently reaches the margin all round. Doubtless, in such cases, the thickness of the translucent nerve-fibre layer alone it is, which is interposed between the sclerotic margin and the margin of the cup all round.

The Normal Retina is so translucent that it cannot be seen; or at most, a shimmering reflection or shot-silk appearance is obtained from it, particularly about the region of the yellow spot and along the vessels, but also towards the equator of the eye, and especially in dark eyes, and in young people.

A peculiar, but physiological, appearance known as opaque nerve fibres is occasionally seen. It is produced by some of the nerve fibres forming the internal layer of the retina regaining the medullary sheath on the distal aspect of the lamina cribrosa, or near the margin of the papilla, which they had lost in the optic nerve just before entering the lamina cribrosa; the rule being that the nerve fibres lose their medullary sheath at the latter place definitely, and enter the retina as axis cylinders only, and hence are quite translucent. Instead of that, in these cases their fibres reflect the light strongly, giving the effect of an intensely white spot, commencing at the disc, extending more or less into the surrounding retina, and terminating in a brushlike extremity. This appearance is constant in the rabbit's eye.

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[1] For explanation of the parallax see chap. xiii.

The Macula Lutea is generally seen as a bright oval ring with its long axis horizontal, this ring being probably a reflex from the surface of the retina. It is remarkable that this halo is not visible with the direct method of examination—a fact due probably to the illumination being much weaker than with the indirect method. The area inside the ring is of a deeper red than the rest of the fundus, and at its very centre there is an intensely red point, the fovea centralis. This ring is not seen in old people.

The General Fundus Oculi surrounding the optic papilla and macula lutea varies a good deal in appearance according to the amount of pigment contained in the chorioid and in the pigment-epithelium layer of the retina. 1. If there be an abundant supply of pigment in each of these positions, the chorioidal vessels are greatly hidden from view, and the effect is that of a very dark red fundus. 2. If there be but little pigment in the pigment-epithelium layer, the larger chorioidal vessels may be visible, and the fundus may appear to be divided up into dark islands surrounded by red lines. 3. If the individual be a blonde, there is little pigment either in the pigment-epithelium layer or in the chorioid, and the fundus is seen of a very bright red colour, the chorioidal vessels down to their fine ramifications being discernible. In albinos even the chorioidal capillaries may be seen.

The Retinal Vessels.—The arteries are recognised as thin bright red lines running a rather straight course, in the centre of each of which is a light-streak. As to the cause of this light-streak there is considerable divergence of opinion.

Some attribute it to reflection from the coats of the vessel, or from the surface of the blood column; while others believe that the light is reflected from the fundus through the vessel, which then acts as a very strong cylindrical lens. This light-streak divides the vessel into two red lines. The veins are darker, wider, and more tortuous in their course than the arteries, and, their coats not being so tense, the light-streak on them is very much fainter.

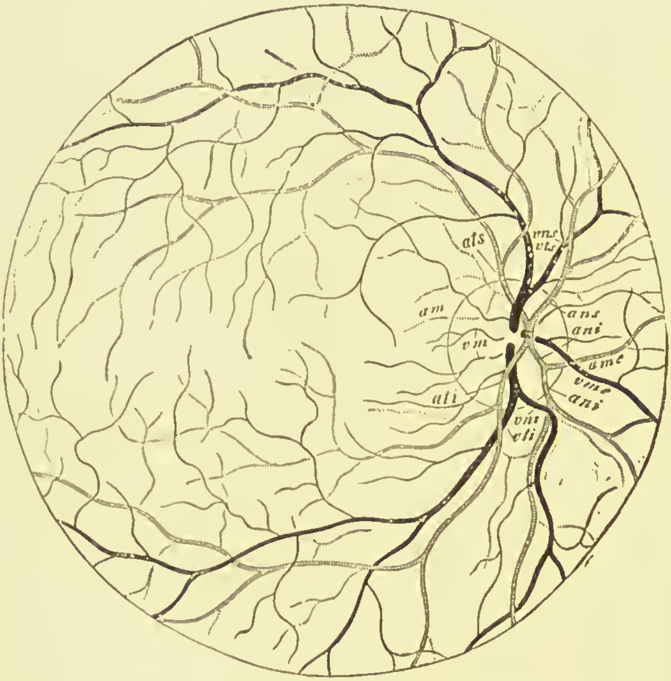

FIG. 88 (*Græfe and Sæmisch*).

a.n.s., Art. nas. sup.; *a.n.i.*, Art. nas. inf.; *a.t.s.*, *a.t i.*, A. temp. sup. and inf.; *v.n.s.*, *v.n.i.*, Ven. nas. sup. and inf.; *v.t.s.*, *v.t.i.*, Ven. temp. sup. and inf.; *a.m.e.*, *v.m.e.*, Art. and ven. median; *a.m.*, *v.m*, Art. and ven. macularis.

On reaching the level of the nerve-fibre layer of the retina the central artery and vein divide into a principal upper and lower branch. This first branching often takes place earlier in the vein than in the artery, and the former may even branch before appearing on the papilla, as in Fig. 88. The second branching may take place in the nerve itself ; and when this occurs it will appear as though four arteries and four veins sprang from the optic papilla; but more usually this branching occurs on the papilla, as in Fig. 88. The vessels produced by this second branching pass respectively towards the median and temporal side of the retina, and are termed by Magnus the Art. and Ven. nasalis and temporalis sup. and inf. (*vide* Fig. 88). The temporal branches run in a radial direction towards the anterior part of the retina. A small horizontal branch, the Art. and Ven. mediana of Magnus, from the first principal branches is found passing towards the nasal side of the retina. The temporal branches do not run in a horizontal direction, but make a *détour* round the macula lutea, sending fine branches towards the latter. Two or three minute vessels from principal branches run directly from the papilla towards the macula lutea, and around the macula lutea a circle of very fine capillary vessels is formed which cannot be distinguished with the ophthalmoscope; but no vessels run to, or cross over, the fovea centralis itself. The retinal arteries do not anastomose, nor do the larger retinal veins. The small retinal veins have some slight anastomoses near the ora serrata. Occasionally a vessel emerges near the margin of the disc, usually at the temporal side. It arises from the ciliary vessels, and is hence called a cilio-retinal vessel (Fig. 87).

No pulsation of the arteries is observable in the normal eye. In the larger veins near or on the optic papilla, or more usually just at their point of exit, a pulsation may sometimes be seen. This venous pulsation is due to the following sequence of events: Systole of the heart; diastole of, and high tension in, the retinal arteries; consequent increased pressure in the vitreous humour ; communication of this to the outside of the walls of the retinal veins, impeding the flow of blood through them, especially in their larger trunks, which offer little resistance, or at their exit from the eye, where they offer the least resistance; and in this way the veins are emptied—the blood gradually coming on from the capillaries overcomes the resistance, and the veins are for a moment refilled. The phenomenon can be most readily observed, if the normal tension of the globe be slightly increased by pressure of a finger during the ophthalmoscopic examination.

CHAPTER V.

DISEASES OF THE CONJUNCTIVA.

THE Conjunctiva, or Conjunctival Sac, consists of three portions: the *palpebral*, lining the inside of the eyelids; the *bulbar*, covering the sclerotic; and the retro-tarsal folds, uniting these two, which form the *sulcus* or *fornix*, upper and lower. When the conjunctiva reaches the margin of the cornea it overlaps the latter slightly, and this overlapping portion is known as the *limbus* conjunctivæ, or corneæ. At the inner angle or canthus, there is a vertical crescentic fold, the *plica semilunaris*, on the nasal side of which is a rounded mass of modified skin called the *caruncle*.

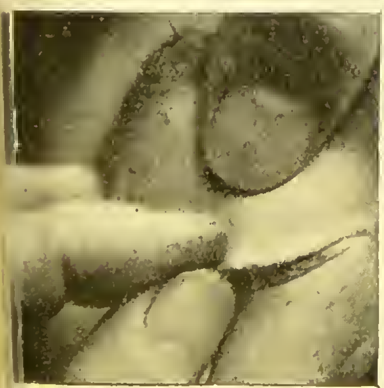

FIG. 89.—First steps in eversion of upper lid.

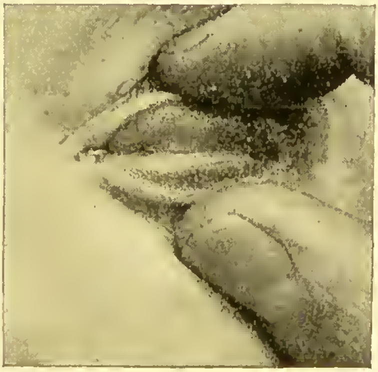

FIG. 90.—Everted lids held in position with one hand.

The Examination of the Conjunctiva.—Simple in- ection in good diffused daylight, the patient facing the indow, is better than artifical illumination. The whole of the mucous membrane should be examined, and for this purpose the lids must be everted. The eversion of the lower lid is a simple matter, but a certain amount of practice is required in the case of the upper lid.

Eversion of the upper lid. – The surgeon should face the patient and direct him to look down and to keep looking down, so as to render the upper edge of the tarsus accessible. The point of the thumb of one hand is then placed on the outer surface of the lid, just above the tarsus, and with it the skin is drawn a little upwards and backwards; this causes the margin of the lid to start forwards. The eyelashes (or the margin of the lid) are then taken between the thumb and forefinger of the other hand, Fig. 89, and raised upwards while the thumb above is depressed. The thumb which acts as the depressor should not be taken away too soon, a mistake often made by beginners, and it is better to slide it away sideways. In case of failure a probe or glass rod can be

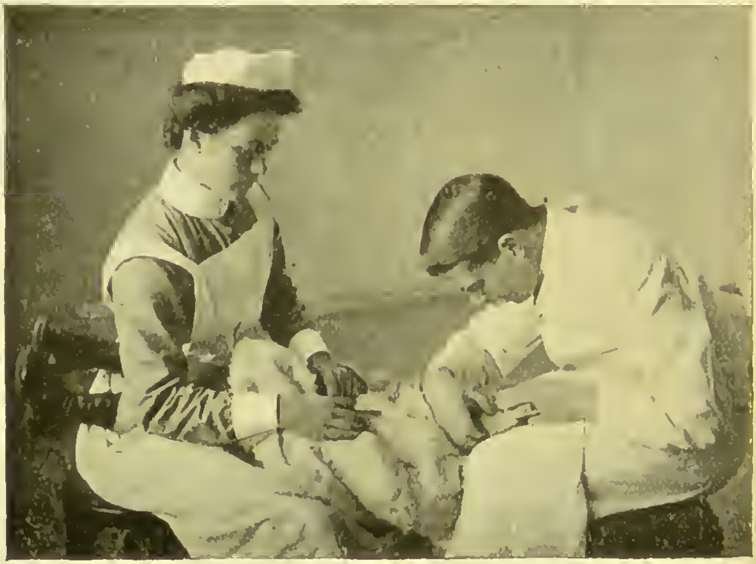

FIG. 91.—Method of examining a child's eye.

used instead of the thumb. When everted, the lids can be retained in position by one hand (Fig. 90), while applications are being made to the conjunctiva.

The method of examining the conjunctiva and cornea in infants and children is shown in fig. 91. The head is firmly held between the surgeon's knees. The conjunctiva is easily inspected, as the lids become everted on merely attempting to open the eye by pulling on the skin near the lid margins. In order to examine the cornea, the lids must not be allowed to become everted, but must be separated with the points of

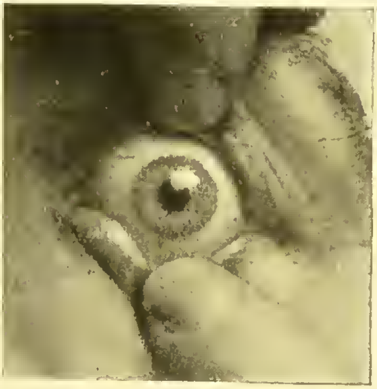

FIG.—92.—Method of exposing a child's eye.

e fingers placed on the ciliary margins as shown in fig. 92. e cornea at first rotates under the upper lid, but soon comes to view. Care must be taken to avoid injuring the cornea ith the finger nails, or using too great pressure on the eye, hich might rupture a corneal ulcer ; and the surgeon must be- re lest retained secretion should spurt up into his own eyes.

The normal conjunctival surface of the upper lid is smooth, llowish pink in colour, and the conjunctiva is adherent to e tarsus. The small branches of the tarsal arches can be n running in a vertical direction, and the meibomian nds appear as yellowish or grey lines at right angles the ciliary margin of the lid. The student should note the appearance and thickness of the edge of the normal tarsus when everted. Figs. 93 and 94 illustrate the method of inspecting the retro-tarsal folds and fornix; the double eversion is necessary in cases of suspected foreign bodies in the fornix.

The blood-vessels of the conjunctiva consist of the posterior conjunctival vessels derived from the palpebral vessels, and the anterior conjunctival vessels which pass backwards from the anterior ciliary vessels. In general affections of the conjunctiva the former are chiefly involved. Engorgement of the vessels of the conjunctiva is known as *conjunctival congestion*, in order to distinguish it from ciliary congestion, which accompanies diseases of the cornea and iris. It is bright red in colour, most marked towards the fornix, and is formed by a network of large, tortuous, superficial vessels, which move with the conjunctiva. *Ciliary Congestion* on the other hand is limited to the circumcorneal area, and diminishes towards the periphery. It is due to engorgement of the episcleral branches of the anterior ciliary vessels. It is pink or violet in colour, and is composed of minute straight radiating vessels, which are frequently indistinguishable to the naked eye as separate vessels. They are situated under the conjunctiva, and cannot be moved with it. In severe inflammations of the eyeball,

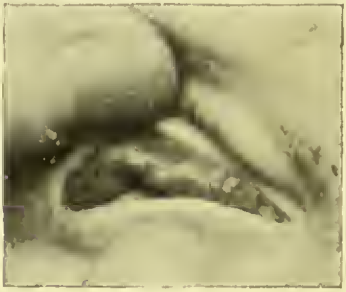

FIG. 93.—Examination of retro-tarsal folds of upper lid.

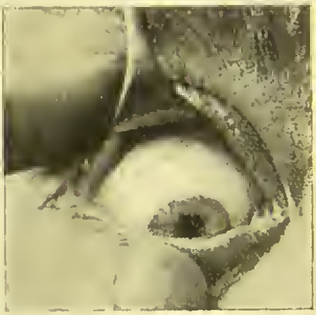

FIG. 94.—Exposure of upper fornix; lid everted and raised with retractor.

such as a purulent ulcer of the cornea, the two forms of congestion are frequently present together.

Hyperæmia of the Conjunctiva.—In this condition the blood-vessels of the palpebral conjunctiva are especially engaged. A slight serous exudation sometimes takes place, which may raise the conjunctiva around the cornea, a condition know as *chemosis* (*χαίνω*, to gape open). Small vesicles may form, and there may be some swelling of the papillæ nd development of lymph follicles. Yet there is not ny abnormal discharge from the conjunctiva, and herein ies the chief clinical difference between this affection and imple conjunctivitis.

Causes.—Foreign bodies. Dust, foul air, or air loaded with obacco-smoke. Alcoholic excesses. Accommodative asthe-opia. Stenosis lacrimalis, and other forms of lacrimal bstruction. The use of unsuitable spectacles, or the use of e eyes for near work without spectacles, when the condi-on of the accommodation (*e.g.*, hypermetropia, presbyopia) equires them.

Symptoms.—The eyes are irritable. There is lacrimation d photophobia, with hot, burning sensations, and sensations of a foreign body in the eye, and the eyelids feel heavy. ll these symptoms are aggravated in artificial light.

Treatment.—In addition to the removal of the cause, the stillation of a drop of tincture of opium and distilled ter in equal parts morning and evening will be found neficial. The eyes should be protected from the glare of ht by dark glasses, and out-of-door exercise is to be ommended.

Conjunctivitis in general.—The term *Ophthalmia* is nmonly used as a synonym of Conjunctivitis,[1] which differs

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Blepharitis is sometimes called Ophthalmia tarsi, and to this there be little or no objection, but the name Sympathetic Ophthalmia is le to mislead, as this disease has nothing to do with the conjunc-, but is an inflammation of the uveal tract.

from mere hyperæmia in the presence of abnormal secretion. Apart from mechanical or chemical irritation, inflammation of the conjunctiva is almost always caused by micro-organisms gaining access to the conjunctival sac; or perhaps in some cases, by the sudden development, under favourable conditions of those which had been already present in a latent condition. They can easily be detected in the discharge, except in the rare cases of metastatic or endogenous origin, and are the cause of its infectious nature. Sporadic cases are very common, but the disease frequently spreads through the members of a household, or occurs as an epidemic. Infection takes place by the direct application of the secretion, or also —it is very generally thought—through the air, in which float particles of the infecting substance. This latter mode is especially liable to exist in an ill-ventilated room, where a number of people affected with conjunctival diseases are lodged with others who possess healthy eyes—*e.g.*, in crowded charity-schools. It must be stated, however, that some authorities dispute the possibility of air-borne infection, upon the ground that most of the organisms which cause the various forms of infectious conjunctivitis are non-sporing, and are readily killed by drying. Inflammations of the conjunctiva are met with in patients of all ages, and at all seasons of the year; but some forms are more common in the spring and autumn. The palpebral conjunctiva is often affected when the bulbar portion remains normal, and the conjunctiva of the lower lid is more frequently attacked than that of the upper lid.

Differential Diagnosis.—The milder forms of conjunctivitis are apt to be mistaken, by those who are inexperienced, for iritis and *vice versa*, but with care there should be no difficulty in distinguishing between the two affections. Conjunctivitis is accompanied by conjunctival congestion, the secretion is muco-purulent, and if not in sufficient quantity to be detected in the conjunctival sac, its presence is indicated by the fact that the lids are gummed together in the mornings. The pain is superficial and limited to the eye itself (sensation of foreign body, heat, itching). Vision is not affected, except temporarily by secretion on the surface of the cornea, which is easily removed by rubbing the lids over the eye. Iritis, on the other hand, is recognised by the presence of ciliary congestion, lacrimation instead of a sticky secretion, and by the character of the pain, which is neuralgic and circumorbital. Moreover, the vision becomes impaired at a very early stage of the disease. The ultimate diagnosis rests of course on the appearance of the iris and on the effect of atropine (see chap. xi.).

Varieties of Conjunctivitis.—Although an accurate diagnosis of the different forms of conjunctivitis depends on he discovery of the particular micro-organism in each ase, nevertheless the usual classification, which is based n clinical appearances, must still be adhered to, partly ecause they are sufficient in most cases to indicate the ne of treatment required, but chiefly because the type inflammation excited by a given microbe is not sufficiently nstant. In the majority of cases no doubt a definite oup of symptoms is associated with a particular micro-ganism, but occasionally the reaction takes a different rm.[1] Again, one and the same clinical picture may be oduced by different micro-organisms. In exceptional cases, , a mixed infection may take place.

From a clinical point of view then, conjunctivitis is ided into different varieties, depending on the nature the discharge, the pathological changes in the tissues, l the severity of the symptoms. In *Catarrhal Conctivitis*, which may be acute or chronic, the discharge is muco-purulent in character, whereas in *Purulent Conjunctivitis* pure pus is secreted. The discharge becomes fibrinous and coagulates to form a membrane, lying on the surface of the conjunctiva, or extending into the substance of the tissues in the *Diphtheritic* form. All inflammations of the conjunctiva are accompanied by more or less increase of the lymphoid tissue, which is of a diffuse character, but in certain cases lymphoid masses are formed which become visible to the naked eye, as in *Follicular* and *Granular Ophthalmia.* In *Phlyctenular Conjunctivitis* small papules, or pseudo-vesicles, are found on the bulbar conjunctiva. Severe cases of conjunctivitis are often attended with slight swelling of the preauricular gland; but in the condition known as *Parinaud's Conjunctivitis* the glandular enlargement is considerable, and reddish vegetations form on the palpebral conjunctiva. *Traumatic Conjunctivitis* may be produced by physical or chemical causes, and inflammation of the lacrimal sac frequently extends to the conjunctiva. In rare cases a *Metastatic Conjunctivitis* due to endogenous infection has been observed. Finally Eczema, Impetigo, and some of the exanthemata (Measles, Scarlatina, Small-Pox) are frequently accompanied by conjunctivitis.

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[1] This may be due to altered conditions, such as differences in the stance of the tissues or blood, or to variations in the degree of lence of the microbe.

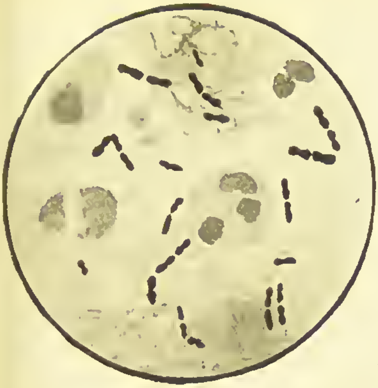
The Bacteriology of Conjunctivitis.—The micro-organisms which are commonly met with as the active causes of conjunctivitis are not very numerous. The following is a list of them, with the clinical type of disease to which each most frequently gives rise :—

Bacilli.

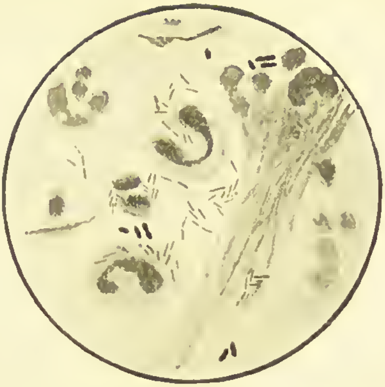
The Koch-Weeks B.—(Acute Contagious Conjunctivitis). The Diplobacillus (Morax)—(Subacute Angular C.). The Diphtheria B.—(Membranous C.).

Cocci.

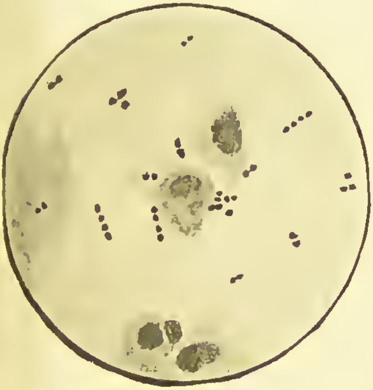
The Gonococcus.—(Purulent C.). The Pneumococcus.—(Catarrhal C.). Streptococcus. Staphylococcus albus et aureus.



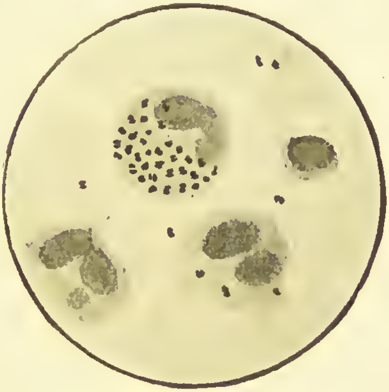
Diplobacillus (*Morax and Axenfeld*). From a case of subacute angular conjunctivitis.



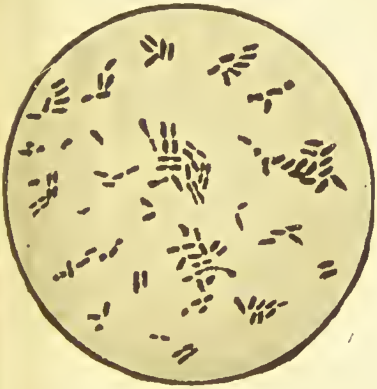
Koch-Weeks bacillus. Secretion from acute conjunctivitis. A few deeply stained *Xerosis b.* are also present.



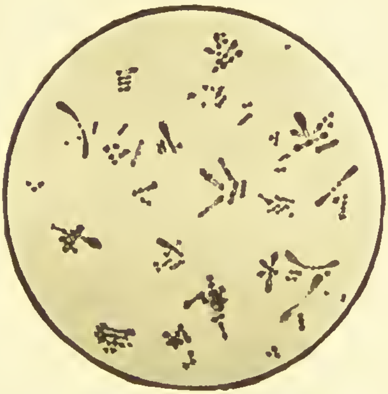
Pneumococcus. From a case of catarrhal conjunctivitis.



Gonococcus. From a case of ophthalmia neonatorum.



Xerosis bacillus. Culture from normal conjunctiva, showing few clubs.



Xerosis bacillus. Culture, diphtheroid form.

From preparations and drawings by L.W.

The last two most frequently occur as part of a mixed infection, along with the gonococcus and the diphtheria bacillus. They are, however, also found, alone or together, in the conjunctivitis (often membranous) which accompanies impetigo of the face, or follows scarlatina, but they have never been known to cause an epidemic.

The Xerosis Bacillus (see Xerosis), which is non-pathogenic, is very frequently present in the normal conjunctiva; but it should also be remembered that some of the pathogenic forms, such as the staphylococcus, pneumococcus, and, it is stated by some, the streptococcus, are also found (especially the first named) in conjunctival sacs devoid of all signs of irritation. In fact the normal conjunctiva is rarely free from micro-organisms.

All the above, with the exception of the gonococcus, the Weeks bacillus, and the diplobacillus, stain by Gram's method.[1]

The number of micro-organisms does not always correspond to the amount of discharge, and in some instances one can be found. We have recently had a case of this ind in which, although the discharge was profuse, both over-glass preparations and attempts to obtain cultures ave negative results on three different occasions. The tiology of such cases is unknown.

In addition to those which have been mentioned, other icro-organisms have occasionally been found. In the se of some of them it is very doubtful if they were e exciting cause of the condition with which they were sociated. The most important varieties will be briefly ferred to as we proceed.

Catarrhal, or **Simple Acute,** or **Muco-purulent Con-**

For clinical work, in most cases, cover-glass smears stained by a sic aniline dye and by Gram's method will suffice, but in some cases identity of the particular microbe can only be established by tures and inoculation experiments.

junctivitis.—In mild cases the affection is confined to the palpebral conjunctiva, often even to the conjunctiva of the lower lid; but in the severer cases it extends to the bulbar conjunctiva. In the latter event the lids may be slightly hyperæmic and swollen. Both eyes are usually affected, either simultaneously, or at a short interval. Lymph follicles and enlarged papillæ are sometimes present. There is a sticky, thin, mucous, or muco-purulent secretion, which causes the eyelids to be fastened together on awaking in the morning, and sometimes produces ulceration of the intermarginal portion of the eyelids (intermarginal blepharitis). In some of the very mildest cases this 'stickiness' or 'gumming' on awaking in the morning is a valuable diagnostic sign, for it is in such cases difficult or impossible to recognise by inspection the very slight variation from the healthy appearance of the conjunctiva.

In the severer cases the papillæ are markedly swollen, and may even conceal the Meibomian glands from view. Also, one often sees small ecchymoses in the bulbar conjunctiva, especially in certain epidemics; but these have no serious import.

Minute grey infiltrations which may break down and form small ulcers, sometimes appear at the margin of the cornea, more especially in old people. When there are many of them they may become confluent and form a small grey crescent, which ulcerates, and thus a crescentic marginal ulcer is formed, and very occasionally such an ulcer is followed by iritis.

The catarrh may become chronic, and then the papillæ are more developed, while the blepharitis is liable to extend over to the cutis, causing eversion of the lower punctum lacrimale with resulting lacrimation, and this, in its turn, aggravates the conjunctival affection. Indeed, chronic conjunctivitis is the commonest cause of ectropion of the lower lid in old people. The chronic form of the disease is much les contagious than the acute, which frequently affects a whole family or may result in an epidemic.

The Symptoms are those of a severe case of hyperæmia (sensations of sand in the eye; hot, burning sensations; weight of the eyelid), with the addition of the annoyance consequent on the secretion, which, by coming across the cornea, may cause momentary clouding of sight. Photophobia is not generally severe unless there be some corneal complication. The symptoms are worse at night, or by artificial light, and are much less troublesome when the eyes are exposed to the air.

Causes.—Anything which favours the entrance of micro-organisms into the conjunctival sac, such as direct infection with secretion, also dust, wind, etc. Conditions which lower the resistance of the tissues, either locally by causing hyperæmia, or generally through the system (impure air, exposure to cold, etc.). Perhaps also the microbes are more widespread or more virulent at certain times, as in the spring or autumn. Some of the above-mentioned causes no doubt act in combination in the conjunctivitis which accompanies impetigo, scarlatina, measles, and small-pox.

The *Koch-Weeks bacillus* produces an acute contagious conjunctivitis, which chiefly attacks young people, and occurs most frequently in an epidemic form.

The type of inflammation resulting from the action of the *Diplobacillus*, on the other hand is of a subacute character, and is attended by a scanty secretion. It causes some redness or excoriation of the lower lids, most marked at the canthi; hence the use of the name *Angular Conjunctivitis.* It is very prone to relapse.

The *Pneumococcus* is responsible for a mild form of atarrhal ophthalmia, occurring generally in children, some-imes in small epidemics. The secretion is at times ibrinous. This variety does not appear to be as common in the United Kingdom as elsewhere. It is of short duration (ten days or so), and can be readily cured.

The conjunctivitis associated with impetigo sometimes assumes a mild catarrhal form. Both *Strepto* and *Staphylococci* are found to be present. The former can no doubt set up conjunctivitis, but attempts to produce conjunctivitis in man with virulent cultures of staphylococcus aureus have proved ineffectual.

In influenza epidemics conjunctivitis sometimes occurs along with the other symptoms, or it may precede them. It is due to the *Influenza Bacillus*, which is shorter and stouter than the Weeks B. but is difficult to distinguish from the latter. It is much rarer in adults than in children.

Quite recently some cases of conjunctivitis have been observed, which were undoubtedly caused by the hay bacillus (*B. Subtilis*). In all of them particles of earth had found their way into the eye.

The Prognosis is good, if there be no reason to suspect that the mild form is but the commencement of a more severe inflammation. The infiltrations, and even the ulcers, which sometimes form at the margin of the cornea are not often of serious import, and usually heal, according as the treatment restores the conjunctiva to health.

Treatment.—It will be advisable here to make a few observations on the treatment of conjunctivitis in general. Patients should always, in the first place, be warned of the danger of infecting others; and in order also to avoid re-infecting themselves, droppers should be sterilized, or at least should not be brought into contact with the eye when used. For bathing the eye sponges should be avoided, and small pieces of lint employed instead, which must be burnt immediately after use. Bandages should not be worn, nor should the patient be confined to the house, unless in severe or complicated cases.

In catarrhal conjunctivitis cold or iced compresses, with the use of a 1 in 5000 solution of sublimate as a lotion, should be used frequently at the onset, and in mild cases will alone bring about a cure. But the habit, which some patients so readily acquire, of bathing the eyes frequently with cold water should not be permitted, for it is deleterious to the conjunctival affection. When in a day or two the irritation and swelling have somewhat subsided—or from the very commencement, if there be not much irritation—a solution of nitrate of silver, of from 5 to 10 grains to ℥j, should be applied by the surgeon to the palpebral conjunctiva with cotton wool twisted on the end of a small piece of stick, such as is used for matches, the lid being well everted. This then should be thoroughly neutralised with a saturated solution of common salt, the whole being finally washed off with plain water. The neutralisation with salt water is very important to check prolonged action of the nitrate of silver, as also to obviate conjunctival staining (called Argyrosis, from ἄργυρος, *silver*) when the treatment is a lengthened one. The application is to be repeated after twenty-four hours, by which time the slight loss of epithelium, the result of the superficial slough, will have been repaired. Immediately after such an application cold sponging or iced compresses are useful, and grateful to the patient. Gentle removal of the loose coagula also gives much relief.

In recent years a number of organic salts of silver have been used instead of the nitrate. The best of these are proargol (20 per cent.) and argyrol (25 per cent.). They do ot coagulate albumen, and are therefore supposed to have reater penetrating power, and are practically painless. n our experience the latter is the better of the two, ut we would still rely on the nitrate in preference to ther.

Even weak solutions of nitrate of silver as eye-drops to be used at home by the patient, should be avoided, for staining is very apt to be caused in this way. Protargol and argyrol have also been observed to cause it.

Should the surgeon be unable to see the patient daily, astringent and antiseptic eye-drops are very beneficial, and indeed often effect a cure. Sulphate of zinc (gr. ij to the ℥j), with or without Tinct. Opii, ʒj, alum (gr. iv to ℥j), tannic acid (gr. v to viij to ℥j) are those which are most commonly used. They may be combined with boracic acid in saturated solution, corrosive sublimate (1—5000), or oxycyanate of mercury (1—2000). Acetate of lead (1 or gr. ij to ℥j) can also be prescribed, provided the cornea be intact; otherwise deposits of lead are liable to form in it. Sulphate of zinc is a specific for diplobacillary conjunctivitis, but the treatment should be continued for some time after recovery, as the affection is very liable to relapse.

A weak boracic acid ointment should be applied along the margins of the lids at bedtime. It prevents the adhesion of the lids in the morning, which is not only unpleasant to the patient, but also prevents free drainage of the secretion during the night.

Acute Blennorrhœa of the Conjunctiva, or **Purulent Ophthalmia.**—This very dangerous affection is most commonly seen either as gonorrhœal ophthalmia or as blennorrhœa neonatorum.

Etiology.—In gonorrhœal ophthalmia the etiological moment is the introduction of some of the specific discharge from the urethra or vagina into the conjunctival sac; while in blennorrhœa neonatorum the infection is believed to take place, either during or just after the passage of the head through the vagina, by abnormal secretion from the latter finding its way into the infant's eyes. A few instances have been observed of infants born with the disease. Prolonged labour, due to early rupture of the membranes, or faulty head presentations, and also repeated examinations, would assist infection before delivery. Inoculation may also occur a few days after birth by pus conveyed by the fingers of the mother or nurse, or by towels, etc., used for washing the child's face.

The more severe cases of blennorrhœa neonatorum are caused by a vaginal discharge, which is almost always gonorrhœal, and Neisser's gonococcus, which is the exciting agent, can be found in the discharge from the vagina and in the secretion from the eye. Mild catarrhal conjunctivitis also occurs in newborn infants, and in these cases the ordinary microbes associated with that condition are present;[1] but in rare cases even the gonococcus may produce mild reaction, probably owing to attenuation of the virus y dilution or drying. It should also be noted that a ypically purulent ophthalmia has, in exceptional cases, een observed in infants (Morax) without the presence f any micro-organisms, but it usually takes a benign ourse.

If the infection take place during or immediately after irth, the disease appears from the second to the sixth day, ccording to the virulence of the secretion. If the inflam-ation come on later than the sixth day, it may be concluded at the infection was produced by the vaginal discharge ing introduced into the eye by the fingers of the mother nurse, etc.

While purulent ophthalmia in adults is usually gonorrhœal d due to the gonococcus, it may exceptionally be the sult of infection by the Koch-Weeks bacillus; the cases e to this bacillus, however, are not so serious as ose caused by the gonococcus. In the rare cases of norrhœal ophthalmia of metastatic origin, the gonococcus cannot be found, as a rule, in the ocular secretion, and the inflammation takes on a mild character. True gonorrhœal ophthalmia is sometimes met with in little girls.

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[1] In some cases the bacterium coli has been found, but that it actu- caused the conjunctivitis is doubtful.

In newborn infants both eyes are commonly affected. The reverse is the case in adults, in whom also the disease is more severe.

Symptoms and Progress.—In mild cases the bulbar conjunctiva may be but little, or not at all, affected, the palpebral conjunctiva alone becoming velvety and discharging a small amount of pus, while there may be no swelling or œdema of the eyelids. In severe cases of blennorrhœa of the conjunctiva there is, soon after the onset, serous infiltration of the palpebral mucous membrane—which consequently becomes tense and shiny—serous chemosis of the bulbar conjunctiva, serous discharge, dusky redness, and swelling of the eyelids —which makes it difficult to evert them—pain in the eyelids, often of a shooting kind, burning sensations in the eye, and photophobia. This first stage, or period of infiltration, lasts from forty-eight hours to four or five days. The preauricular lymphatic glands may be swollen and tender, and a rise of temperature may occur.

Then begins the second or purulent stage, in which, owing to swelling of the papillæ, the palpebral conjunctiva becomes less shiny and more velvety; while the discharge alters from serous to the characteristic purulent form, the chemosis, however, remaining unaltered, or becoming more firm and fleshy. The swelling of the lids continues, the upper lid often becoming pendulous and hanging down over the under lid; while, at the same time, it becomes less tense and more easily everted. Gradually the chemosis and swelling of the conjunctiva and eyelids subside, and the discharge lessens, the mucous membrane finally being left in a normal state, unless in a small percentage of cases in which chronic blennorrhœa remains. A moderately severe attack of conjunctival blennorrhœa lasts from four to six weeks. A delicate scarring of the conjunctiva in the fornices may be sometimes left after the attack.

Complications with corneal affections form the great source of danger from this affection. They are found chiefly in four different forms. (1) Small epithelial losses of substance on any part of the cornea. If these occur at the height of the inflammation, they are apt to go on to form deep perforating purulent ulcers. (2) The whole cornea becomes opaque (diffusely infiltrated), and towards its centre some greyish spots form, which are interstitial abscesses or purulent infiltrations. (3) The infiltration may form at the margin of the cornea, and extend a considerable distance around its circumference, giving rise to a marginal ring ulcer, and, later on, to sloughing of the whole cornea. (4) A clean-cut ulcer may form at the margin of the cornea without any purulent infiltration of the corneal tissue, and may also extend a long way round the cornea. Such ulcers are particularly apt to occur where there is much chemosis, which overlaps the margin of the cornea; and, being hidden in this way, these ulcers are easily overlooked. The chemosis hould be pushed aside with a probe, and these peculiar ulcers ooked for. They are very liable to perforate.

All the foregoing forms of corneal complication occur both n ophthalmia neonatorum and in gonorrhœal ophthalmia. hey may appear at any period of the affection, but the arlier they occur the more likely are they to result seriously. The danger of these ulcers consists in the perforation of he cornea they are apt to produce, of which more later on. The severer the case, especially the more the bulbar con- nctiva is involved in the process, the more likely is it that rneal complications will arise. For the corneal process is be regarded as the result of infection by the conjunctival cretion; and this infection is all the more apt to occur, here the nutrition of the cornea is impeded by a dense emotic swelling of the bulbar conjunctiva. Severe chemosis is less common in the blennorrhœa of the new-born than in gonorrhœal ophthalmia, and this may be the reason for the fact that the latter is much the more dangerous affection of the two.

The Prophylaxis of purulent ophthalmia is a most important matter. It should form part of the routine of lying-in practice. Careful disinfection of the vagina before and during birth, and the most minute care in cleansing the face and eyes of the infant immediately after birth with a non-irritating disinfectant (*e.g.*, a solution of corrosive sublimate 1 in 5000), are to be recommended. The method of the late Dr. Credé has found very general acceptance, and is an admirable one. It is as follows:—When, after division of the umbilical cord, the child is in the bath, the eyes are carefully washed with water from a separate vessel, the lids being scrupulously freed, by means of absorbent wool, of all blood, slime, or smeary substance; and then, before the child is dressed, a few drops of a 2 per cent. solution of nitrate of silver are instilled into the eye. Many obstetricians employ this method now as a matter of routine in their lying-in hospitals for all the infants, whether or not it be suspected that there is danger of infection. The conjunctival irritation which sometimes follows this procedure is unimportant compared with the immense advantages which result from it. By its aid Credé reduced the percentage of his cases of ophthalmia neonatorum from 8 or 9 per cent. to 0·5 per cent.

In all cases of gonorrhœa it is the duty of the surgeon to explain to his patients what is the danger of their carrying any of the urethral discharge to their eyes; and to charge them to exercise punctilious cleanliness as regards their hands and finger-nails, and care in the use of towels, handkerchiefs, etc.

In respect of *Local Treatment* when the disease has become established:—In the very commencement of the affection the only local applications admissible are antiseptic lotions (Permanganate of Potash Solution, 1 in 10,000; Sublimate, 1 in 5000) and iced compresses, or Leiter's tubes. With the former the conjunctival sac should be freely washed or irrigated—not syringed—out. In syringing out the conjunctival sac a morsel of the corneal epithelium may be removed, and through this the cornea become infected, and therefore this method is objectionable. The iced compresses, or Leiter's tubes, should be kept to the eye for an hour at a time, with a pause of an hour, and so on, or even continuously. In this and in the next stage the chemosis should be freely, and daily, incised with scissors. If the swelling of the lids be great, the external canthus should be divided with a scalpel from without, leaving the conjunctiva uninjured, in order to reduce the tension of the eyelids on the globe, and, by bleeding from the small vessels, to deplete the conjunctiva. Depletion alone can be obtained by leeching at the external canthus, and in many cases is of great benefit at the very commencement. If in adults the chemosis, palpebral swelling, and rapidity of the onset indicate that the inflammation is severe, it is well to place the patient quickly under the influence of mercury by means of inunctions or small doses of calomel, as by so doing the chemosis is often rapidly brought down, and one source of danger to the cornea removed.

In the second stage (*i.e.*, when the conjunctiva has become velvety, and the discharge purulent) caustic applications are the most trustworthy, and in this respect iodoform and other lauded means cannot compete with them. The application employed may be a solution of nitrate of silver of 15 to 20 grains in ℥j of water, which should be applied by the surgeon to the conjunctiva of the everted lids, and then neutralised with a solution of common salt; or the solid mitigated nitrate of silver (one part nitrate of silver, two parts nitrate of potash) may be used, the first application being lightly made in order to test its effect, while careful neutralisation with salt water and subsequent washing with fresh water are most important. Iced compresses may be used to relieve pain. An interval of twenty-four hours should elapse before the application is renewed. No remedy is of greater value in purulent ophthalmia than mitigated lapis, when the proper indications for its use are present, and when it is applied with care and intelligence. Between the caustic applications, the pus should be frequently washed away from the eyelids, and from between the eyelids, with a 4 per cent. solution of boric acid, or with a 1 in 5000 solution of corrosive sublimate, and boric acid ointment should be smeared along the palpebral margins, to prevent them from adhering, and thus retaining the pus.

No corneal complication contra-indicates the active treatment of the conjunctiva by the method just described. Iodoform, finely pulverised, has been much praised as a local application in the second stage of acute blennorrhœa of the conjunctiva. It is to be dusted freely on the conjunctiva once or twice a day. For our part we should trust to it alone in mild cases only. It can, however, be employed with advantage in combination with the above treatment.

Permanganate of potash in solution (1 in 5,000) is strongly recommended by some surgeons as a substitute for nitrate of silver, even in severe cases. They state that it can be used from the beginning, and with greater benefit. The conjunctival sac should be washed out with it three or four times a day.

When but one eye is affected it is important to protect its fellow from infection by means of a hermetic bandage. This may be made by applying to the eye a piece of lint covered with boracic acid ointment, and over this a pad of borated cotton-wool. Across this, from forehead to cheek and from nose to temporal region, are laid strips of lint soaked in collodion in layers over each other; or a piece of tissue guttapercha may take the place of the lint and collodion, its margins being fastened to the skin by collodion. The shields invented by Maurel and by Buller are serviceable for this purpose. Yet with careful instructions given to the patient, and average intelligence on his part, such protection of the sound eye is not necessary. In private cases we do not close the second eye, and have never had ill effects in consequence. Any sign of congestion was met by the application of a 2 per cent. solution of nitrate of silver, and it always proved sufficient to check the development of the disease, as it does in Credé's method of prophylaxis.

Patients should be advised to sleep on the side of the affected eye, in order to prevent the discharge from trickling on to the other side of the face.

Treatment of Corneal Complications.—The involvement of the cornea does not contra-indicate the use of the methods already described, but rather demands their vigorous application. In addition, atropine will relieve pain and diminish the tendency to iritis. Eserine is sometimes employed with the object of reducing the tension, and so improving the nutrition of the cornea by facilitating the lymph circulation, and also on account of its antiseptic properties. But, as its action on the normal tension is practically nil, and its antiseptic properties are very slight, it is better to reserve it for cases of marginal ulcer with prolapse, or danger of prolapse, of the iris, since by the contraction of the sphincter the iris is drawn away from the periphery. Greater care is now required in everting the lids, lest pressure on the globe should cause rupture of the ulcer; and it must be remembered that when a case of acute blennorrhœa first presents itself, the surgeon, not knowing the condition of the cornea, must use the utmost caution in making his examination, and yet must never fail to get a view of the cornea for the purposes both of prognosis and of treatment. At each visit the cornea must be examined, and it may be found that, as the conjunctival process subsides, any existing corneal affection also progresses towards cure, infiltrations becoming absorbed and ulcers filled up. But even though the conjunctiva be improving, and still more so if it be not, the corneal process may progress, the infiltration becoming an ulcer, and the ulcer becoming gradually deeper, until, finally it perforates.

Should a corneal ulcer become deep, and seem to threaten to perforate, paracentesis of the floor of the ulcer must be resorted to without delay. By thus forestalling nature a short linear opening is substituted for the circular loss of substance, which would have resulted in the ordinary course of events. Through this small linear opening no prolapse of the iris, or else a relatively small one, takes place; and consequently the ultimate state of the eye is usually a better one than it otherwise would have been. The reduction of the intraocular tension after the paracentesis promotes healing of the ulcer. It is often desirable to evacuate the aqueous humour, by opening the little incision in the floor of the ulcer with a blunt probe, on each of the two days after the operation.

If an ulcer perforate spontaneously, the aqueous humour is evacuated, and, unless the ulcer be opposite the pupil and at the same time small in size, the iris must come to be applied to the loss of substance. Should the latter be very small, the iris will simply be stretched over it and pass but little into its lumen, and when healing takes place will be caught in the cicatrix, which is but slightly, or not at all, raised over the surface of the cornea, and the resulting condition is called Anterior Synechia.

If the perforation be larger, a true prolapse of a portion of the iris into the lumen of the ulcer takes place. This prolapse may either act as a plug, filling up the loss of substance and keeping back the contents of the globe, but not protruding over the level of the cornea, or it may bulge out over the corneal surface as a black globular swelling, and may then play the part of a distensor of the opening, causing fresh infiltration of its margins. In either case cicatrisation will eventually occur; and if the scar be fairly flat, it is called an Adherent Leucoma, but if it be bulged out, the term Partial Staphyloma of the Cornea is used.

If the perforation be very large, involving the greater part of the cornea, with prolapse of the whole iris and closure of the pupil by exudation, the result is a Total Staphyloma of the Cornea. The lens may lie in this staphyloma, or it may retain its normal position, but become shrunken.

The question of the treatment of a recent prolapse of the iris in cases of blennorrhœic conjunctivitis is an important one. It has been, and is still largely, the practice to abscise small iris-protrusions down to the level of the cornea, or if large to cut a small bit off their summits, with the object of obtaining flat cicatrices. Horner pointed out that in cases of blennorrhœa this proceeding opens a way for purulent infection of the deep parts of the eye, and that serious consequences are not rare. He confined interference with the iris in these eyes to incision of the prolapse, when it seems to be acting as a distensor of the opening, causing fresh infiltration of the cornea. Under other circumstances he restricted his treatment of the prolapse to the instillation of eserine, which has a marked effect in diminishing the size of the protrusion.

A method of treating corneal ulcers of which we have no experience in purulent ophthalmia, but from which we have obtained good results in other cases, consists in covering the ulcer with conjunctival flaps. Goldzieher and Kuhnt speak favourably of the results obtained by this method in purulent cases. The conjunctival sac should first be thoroughly washed out with a weak antiseptic or sterilized salt solution and any prolapse of the iris should be removed. (See also chap. vii.).

It may occur that on the surgeon's visit to a case of blennorrhœa of the conjunctiva, he will find the margins of the eyelids gummed together by sero-purulent secretion, while the eyelids are bulged out by the pent-up fluid behind them. The attempt to open the eye should then be very cautiously made, lest some of the retained pus spurt into the surgeon's eye. The surgeon should also be most careful to thoroughly wash and disinfect his hands and nails at the conclusion of his visit.

In cases of blennorrhœa neonatorum, when the ulcer has been small, on perforation taking place, the lens, or rather its anterior capsule, comes to be applied to the posterior aspect of the cornea. The pupillary area is soon filled with fibrinous secretion. The opening in the cornea ultimately becoming closed, the iris and lens are pushed back into their places by the aqueous humour which has again collected. Adherent to the anterior capsule on the spot which lay against the cornea is a morsel of fibrine, which gradually becomes absorbed by the aqueous humour. In the meantime changes have been produced by this exudation on the corresponding intracapsular cells, which result in a small, permanent, central opacity at that place, where there is also a slight elevation of pyramidal shape over the level of the capsular surface. This condition is called central capsular cataract, or pyramidal cataract, and rarely results from corneal perforation in adults.

In cases of blennorrhœa neonatorum an inflammatory swelling of the joints, so-called gonorrhœal arthritis, is very occasionally seen. The gonococcus has been found in the fluid removed from the joints in some cases, while in others only the usual pyogenic cocci were present. Even more rarely do peri- and endo-carditis, pleuritis, and meningitis occur.

* **Membranous Conjunctivitis.**—This disease is char-

acterised by the existence of a fibrinous exudation, either on the surface or in the substance of the conjunctiva, in addition to the other symptoms of inflammation. It was formerly believed, on purely clinical grounds, that the mild form of the disease, known as croupous conjunctivitis, was totally different in nature from the severe or diphtheritic form, and later on this view seemed to be borne out by the discovery of the Klebs-Loeffler bacillus in the diphtheritic cases; but further experience of the bacteriology of membranous conjunctivitis has altered this view. Not only is the diphtheria bacillus found in mild croupous cases, but any of the micro-organisms which commonly cause conjunctivitis, may give rise to fibrinous exudations and the formation of membranes. The same condition in varying degrees of severity can be produced by chemical irritants such as lime, ammonia, etc., and also by jequirity. Lastly, the diphtheria bacillus may, in rare cases, lead to a simple catarrhal inflammation without the production of a membrane. The presence of a membrane therefore is only a symptom and is not necessarily pathognomonic, although very suggestive of the Klebs-Loeffler bacillus as the cause.

In severe cases strepto- and staphylo-cocci are generally asociated with the diphtheria bacillus, and indeed the streptococcus, staphylococcus, and pneumococcus acting alone can cause severe membranous inflammation with loss of the sight.

There is reason to believe that the diphtheria bacillus can only act on the conjunctiva when the epithelium has been injured, say by a slight, even imperceptible trauma or a previous inflammation.

Two micro-organisms which are closely related to the true diphtheria bacillus and which must be distinguished from it, are the non-pathogenic B. xerosis and the avirulent diphtheroid bacillus. Since morphological and cultural differences are of doubtful value in separating the virulent from the non-virulent forms, inoculation experiments are necessary to establish an accurate diagnosis.

Microscopically the membrane consists of a fibrinous network containing leucocytes, a few epithelial cells and often micro-organisms. In the so-called croupous cases the underlying epithelium may or may not be adherent to it, but even in the latter event, although the epithelium separates along with the membrane, the surface left is smooth and becomes covered by regenerated epithelium, so that no trace of scarring occurs.

On the other hand, in the severe or diphtheritic cases the submucous tissue is involved in the exudation, the vessels become compressed by it, and this leads to necrosis. When the dead tissue has been cast off a granulating surface is exposed which heals by cicatrisation. These are true granulations in the surgical sense, and are therefore quite different from the granulations of trachoma.

Etiology.—Membranous conjunctivitis in all degrees of severity is mostly met with in children, more especially under four years of age. It often follows an attack of measles or scarlatina, and is frequently accompanied by eczema.

One or both eyes may be attacked. It is an acute disease, which occurs sporadically or in epidemics, but a few chronic cases have been seen lasting for many months.

Clinically, the mild or croupous form of the disease can readily be distinguished from the severe or diphtheritic; hence they will be described separately, with the understanding that the real nature of each case only be decided by careful bacteriological examination.

Croupous Conjunctivitis.—The symptoms are those of catarrhal conjunctivitis, to which in a few days is added the appearance of a greyish pellicle on the palpebral conjunctiva, sometimes also on the retro-tarsal folds, but rarely on the bulbar conjunctiva. The false membrane can be peeled off, leaving a mucous surface underneath which may or may not bleed. The lids, which may be red and swollen, are always soft and easily everted. After a week or so the second or secreting stage sets in, with the appearance of a discharge, and the false membrane becomes separated, leaving a healthy mucous surface which gradually returns to its normal condition, without any trace of scarring. Observations with reference to corneal complications vary in their results, some surgeons never having seen them while others have noted them in 40 per cent. of their cases. Constitutional symptoms are much less frequent than in the severe or diphtheritic variety of this affection.

Treatment.—In the first stage iced compresses or Leiter's tubes applied to the lids, with antiseptic cleansing of the conjunctival sac. No caustic should be used in this stage, as it is apt to produce corneal changes. Sulphate of quinine sprinkled on the conjunctiva or in 2 per cent. solution is praised by some surgeons as a useful application at this period. In the secreting stage nitrate of silver applications should be made in the usual way.

When the Klebs-Loeffler bacillus is the active agent antitoxin should be used. According to some, simple instillations into the conjunctival sac may suffice in these mild cases. (See Treatment of Diphtheritic Conjunctivitis.)

Diphtheritic Conjunctivitis.—There is no more serious ocular disease than this, for it may destroy the eye in twenty-four hours ; while in severe cases treatment is almost powerless. Fortunately it is almost unknown in these countries.

The subjective symptoms of its initial stage are similar, although severer, especially in the matter of pain, to those of blennorrhœic conjunctivitis. The objective symptoms differ from those of blennorrhœa, in that the lids are excessively stiff, owing to plastic infiltration of the sub-epithelial and deeper layers of the conjunctiva, while the surface of the mucous membrane is smooth, and of a greyish or pale buff colour. If an attempt be made to peel off some of the superficial exudation the surface underneath will be found of the same grey colour, not red and vascular, as in croupous conjunctivitis. This *stage of infiltration* lasts from six to ten days, and constitutes the period of greatest peril to the eye; for while it lasts the nutrition of the cornea must suffer, and sloughing of that organ is extremely apt to take place. Towards the close of the first stage the fibrinous infiltration is eliminated from the eyelids, and the conjunctiva gradually assumes a red and succulent appearance, and at the same time a purulent discharge is established. This constitutes the second or *blennorrhœic stage.* A third stage is formed by *cicatricial* alterations in the mucous membrane, which often lead to symblepharon, or to xerophthalmos; so that, even if the eye escape corneal dangers in the first and second stages, others almost as serious may await it in the final stage.

Corneal complications are most likely to occur in the first stage, and are then also most likely to prove destructive to the eye. The earlier they appear the more dangerous are they. If the blennorrhœic stage come on before corneal complications appear, or even before an ulcer contracted in the first stage has advanced far, they are more easily controlled.

In the third stage corneal affections, if they occur, are of a chronic nature and generally accompanied by vascularisation.

This disease is nearly always combined with constitutional symptoms, such as fever, malnutrition, albuminuria, and is sometimes fatal, but strange to say, is very rarely followed by paralysis, even of accommodation. It has seldom been observed to follow diphtheria of the throat, although the opposite sequence is not uncommon.

Treatment.—If due to the Klebs-Loeffler bacillus antitoxin serum is the sovereign remedy, and as the injections should be made as soon as possible, and the identification of the diphtheria bacillus takes time, any presumption of its presence should be acted upon without delay. Precautions should of course be taken to avoid the transference of the disease to others. In cases caused by the pneumococcus Römer's pneumococcus serum[1] may be used. These remarks also apply to croupous conjunctivitis.

Local treatment in the first stage should consist in cold or iced applications and antiseptics; later on warm fomentations, especially if the patient finds them more agreeable, can with advantage be substituted for the cold. In the secreting stage the same lines of treatment should be followed as in catarrhal conjunctivitis, except that greater precaution should be taken in using the nitrate of silver; the greater the discharge the more freely it can be applied, and *vice versa.* Corneal ulcers must be dealt with, whenever they arise, in the same way as though the case were one of blennorrhœic conjunctivitis. When the purulent discharge ceases, solutions of soda, milk, or glycerine may be prescribed as lotions for the conjunctiva, to arrest, if possible, the xerophthalmos.

* **Hay Fever.**—This is not uncommon among the better classes in these countries, although it is rarely seen in our hospital out-patient departments. The symptoms, in those liable to it, appear in the early summer each year, and disappear again in the course of six weeks or two months. They consist in catarrh of the nostrils, accompanied by great itching of them and frequent sneezing; while the conjunctiva, especially in the lower fornix, becomes somewhat hyperæmic, and there is lacrimation. There is excessive itching of the eyes, which renders the patient most wretched, and forces him to rub his eyes violently. There is photophobia. The respiratory tract may become involved, with some bronchitis

and asthma, and general malaise and elevation of temperature are present. Sometimes the eyes alone are affected. There is no tendency to corneal complications.

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[1] *Archiv für Augenheilk*, lii. p. 1.

Treatment is of no avail in preventing the annual recurrence of the affection, nor is it of much use in alleviating the attack. No strong local application should be employed. Weak collyria, or ointments, of sulphate of zinc, or copper, boric acid, or sublimate, etc., may be tried. Cocaine or holacaine eye drops (2 per cent.) afford the best relief. Dark glasses should be worn.

Dunbar's hay fever serum called pollantine, has been used with benefit in some cases.[1]

Trachoma (τραχύς, *rough*), **Granular Conjunctivitis,** or **Granular Ophthalmia** (also called Egyptian Ophthalmia and Military Ophthalmia).—In this disease, in addition to the usual appearances of simple conjunctivitis, there are developed translucent greyish or pinkish-grey bodies about the size of the head of a pin or larger, situated in and close to the fornix conjunctivæ, chiefly of the upper lid. They also occur on the tarsus, in the lower fornix, and sometimes on the plica semilunaris, but are very rarely met with on the bulbar conjunctiva. The tarsal growths are smaller, flatter, and yellower in colour than those seen in the fornix. These bodies are the trachoma bodies or granulations, or "sago" grains, they somewhat resemble the follicles of follicular conjunctivitis, except that they are paler, more irregular in size and less apt to occur in rows.

Microscopically they exhibit the structure of *lymphoid follicles*, and consist of an outer zone of small lymphocytes and a central mass of larger endothelioid cells, amongst which some very large cells are found with irregular processes and cell-inclusions. These are the so-called "trachoma cells" or "corpuscle cells"; they are supposed to be phagocytes or enlarged connective tissue cells, and have even erroneously been taken for protozoa, but since they exist in normal lymph follicles in other places, they are not in any sense specific. The cellular elements of the follicle lie in the meshes of a delicate reticulum, the follicle itself being surrounded by a vascular network and a more or less defined capsule.

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[1] *Deutsch. Med. Wochenschrift*, 1903, No. 9, p. 149.

The unevenness of the conjunctival surface is still further increased by a luxuriant formation of *papillæ* due to the folding of the inflamed and hypertrophied mucous membrane, which also leads to the development of microscopic glands and later on of small cysts. The latter are met with in the furrows between the papillæ, or they may be produced by solid downgrowths of epithelium, which become softened in the centre. The follicles ultimately become absorbed, or soften, and according to Raehlmann, extrude their contents on the surface. In any case their disappearance is followed by the development of fibrous cicatricial tissue, from the shrinking of which various complications, which shall be mentioned later on, ensue. The tarsus may be involved in the inflammation, and in most cases a vascular, richly cellular layer (Pannus) forms in the cornea between the epithelium and Bowman's membrane.

Etiology and Cause.—There can be no doubt that this disease is contagious and that it is the result of a specific cause, of the nature of which we are at present ignorant. The numerous bacteriological examinations which have been made and even the recent ultramicroscopic investigations of Raehlmann have led to no definite results. The histological changes are not peculiar to this disease alone—the papillary hypertrophy is well seen in chronic blenorrhœa, for instance—and even lymph follicles occur from other causes; for example, from atropine irritation and in tuberculosis. It may be that granular ophthalmia is something of the nature of the infective granulomata.

Infection occurs only by transference of the secretion from one eye to the other by means of fingers, towels, handkerchiefs, etc. Hence the more slovenly in their personal habits, and the more crowded in their dwellings, families, schools, barracks, or nations may be, the more likely is this disease to spread from one individual to another when it once gains a foothold. A great deal, however, remains to be learned as to the manner in which contagion takes place. The infectiousness of chronic cases cannot be very great, for nurses and doctors rarely, if ever, become infected by their patients. Neither do we see trachoma patients infecting other patients in the hospitals in this country, where the disease is so prevalent. Were the infectiousness of the disease very great, even the precautions taken in a well-ordered hospital against contagion would hardly be sufficient to prevent such an occurrence occasionally.

Amongst the better classes, both here and elsewhere, the disease is very uncommon. High, dry, mountainous countries are almost free from it, so that, probably, the atmospheric conditions play some part in the etiology.

Some hold that the affection is dependent on constitutional disease, such as scrofula, tuberculosis, syphilis, etc. ; but we cannot endorse this view. No doubt many of these patients are anæmic and out of health, but this is due to the moping habits they contract, and the little open-air exercise they take in consequence of their semi-blindness.

The effect of race as a predisposing cause is doubtful. Jews are said to be peculiarly liable to the disease, but it must be remarked that in them as in others it only occurs amongst the very poor.

Trachoma generally attacks both eyes and is an extremely chronic affection. An acute form is described, which, however, must be very rare, as it is practically non-existent in Ireland, although the chronic variety of the disease is so common.

Acute Trachoma, or *Acute Granular Ophthalmia.*—The symptoms are those of a more or less acute purulent ophthalmia, associated with the characteristic appearances of trachoma. But it has been proved in many cases that the acute symptoms are really due to an additional infection by the gonococcus or Koch-Weeks bacillus, and therefore the diagnosis of acute trachoma cannot be depended upon without a careful bacteriological examination.

Treatment.—In the early stage the treatment is the same as for acute blennorrhœa, while at a later period the same methods are adopted as in chronic trachoma.

Chronic Trachoma, or *Chronic Granular Ophthalmia.*—This disease is often unaccompanied by inflammation, and is then unattended by any distressing symptoms, except that the eye may be more easily irritated by exposure to cold winds, foreign bodies, etc., or more easily wearied by reading and other near work. At this period the conjunctiva will be found free from injection or swelling; but greyish-white semi-transparent trachoma bodies, of the size of a rape-seed and less, will be seen disseminated over the conjunctival surface and protruding from it. Gradually these trachoma bodies or granulations give rise to a more or less active vascular reaction, attended with swelling of the papillæ and purulent discharge—in short, slight blennorrhœa. This is the *stage of progression* (Fig. 95). The patients then begin to be more inconvenienced, owing to the discharge which obscures their vision, to sensations of weight in the lids and of foreign bodies in the eye, and to partial ptosis, which is often observable; and this, consequently, is generally the earliest stage at which we see the disease. The enlarged papillæ often grow to a great size, completely hiding the granulations. In this stage the granulations may become absorbed, and the disease undergo cure; but more commonly it makes further progress. Fresh granulations appear, while the old ones increase in size and undergo a peculiar gelatinous change. They then often become confluent, leaving only here and there an island of vascular mucous membrane. Sometimes the trachoma bodies are very small, and present the appearances of minute yellowish dots, and in this form they are not always easily found.

Gradually the follicles become absorbed, or more rarely their contents are expelled, and the connective tissue proliferates so as to cause more or less extensive scarring of the conjunctiva. This constitutes *the cicatricial stage* of the disease. The scarring frequently presents a reticulated appearance, and in many cases assumes the form of a white line parallel to, and a few millimetres from, the free margin of the lid, Fig. 96. The tarsus may undergo fatty degeneration or become hypertrophied, while the diseased conjunctiva on the inner surface of the lid causes entropion and distortion of the bulbs of the eyelashes, followed by irregular growth of the latter, with resulting trichiasis and distichiasis. These changes are represented in Fig. 97.

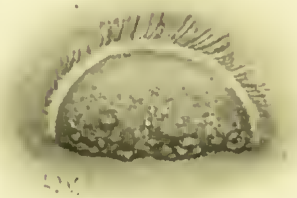

FIG. 95—Granular ophthalmia: progressive stage.

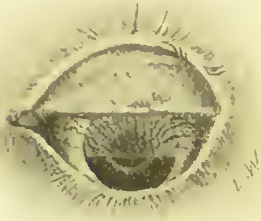

FIG. 96—Granular ophthalmia; cicatricial stage, with pannus and trichiasis.

The great danger of granular ophthalmia lies in the complications which may attend it or which follow in its wake; the former consist in pannus, ulcers of the cornea, and severe purulent conjunctivitis, while the latter are the distortions of the lids and eyelashes just referred to.

Pannus (*Lat.*, a cloth rag) presents the appearance (Fig. 96) of a superficial vascularisation of the cornea, with more or less diffuse opacity, and often small infiltrations. It invariably commences in the upper portion of the cornea, extending generally over the upper half, and frequently remains confined to this region. But in many cases, at a later stage, it extends to the whole surface of the cornea; this latter occurrence often takes place almost suddenly,

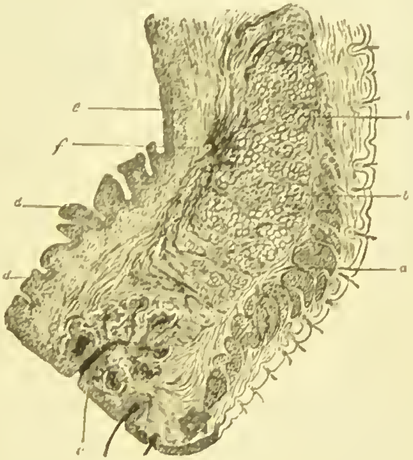

FIG. 97 (*Sæmisch*).

a, Muscle; *b b*, Tarsus having undergone fatty degeneration; *c*, Atrophied leibomian Gland; *d d*, Hypertrophied Papilla; *e*, Cicatricial Tissue in the con-unctiva; *f*, Tarsus.

nd the vascularisation and opacity sometimes become so ntense as to present quite a fleshy appearance, completely iding the corresponding part of the iris from view. Iistologically pannus consists of a new growth, which is xtremely rich in cells, and which closely resembles the onjunctiva when occupied with confluent granulations. It in fact a vascular granulation tissue which grows in om the limbus and is situated between the corneal pithelium and Bowman's layer. After a length of time owman's layer becomes destroyed in places, and then the cellular infiltration gains access to the true cornea, and gives rise to permanent changes in its transparency and curvature. In some bad cases of old-standing pannus the latter undergoes a connective-tissue change. It then becomes smooth on the surface, and the vessels almost disappear, so that the cornea is covered with a thin layer of connective tissue, which obstructs the passage of light and is not capable of cure. Small white deposits occur sometimes at the lower edge of the pannus near the centre of the cornea, they are superficial and can be easily scraped off.

Another result of pannus, sometimes, is a bulging or staphylomatous condition of the cornea, the tissues of which have become so altered and weakened that they give way before the normal intraocular tension.

A pannus in which as yet there is no connective tissue alteration, and where there is no staphylomatous bulging, is capable of undergoing cure without leaving any opacity behind, except that which may be due to ulcers that have been present.

Pannus is usually a painless affection, but is sometimes accompanied by photophobia and ciliary neuralgia. It may come on at any stage of the disease, and causes defective vision, in proportion to the degree and extent of the opacity. Severe pannus is liable to induce iritis.

The connection between pannus and the condition of the conjunctiva is not altogether evident. It was for long held that the corneal affection is due to mechanical irritation, caused by the rough palpebral conjunctiva; but some are opposed to this view, and indeed severe pannus is often seen with a comparatively smooth conjunctiva, while with a truly rough conjunctiva the cornea is frequently perfectly clear.[1] There can now be little doubt that pannus is analogous to the granular disease in the conjunctiva. It is, in fact, the same disease modified by reason of the different tissue in which it is situated, this different tissue being itself a modification of the conjunctiva; and it would seem probable that the cornea becomes diseased by direct inoculation from the conjunctiva of the upper lid. Yet it is remarkable that the bulbar conjunctiva, lying between the upper margin of the cornea and the fornix of the upper lid, never becomes apparently diseased.

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[1] Harman (*The Conjunctiva in Health and Disease*: London, 1905) points out that a conjunctiva which looks rough is sometimes soft to the touch, and *vice versa*.

Prognosis.—At any period prior to cicatrisation of the conjunctiva an attack of purulent blennorrhœa is liable to come on. If not too severe, this may result in a cure by absorption of the trachoma bodies, and should not be checked. If, however, the attack be very severe, the eye runs dangers similar to those of an ordinary attack of purulent conjunctivitis. These dangers are less the more complete and the more intense the pannus.

On the whole, if the disease come under care at an early period, and if treatment be carried out strictly, vision will be retained in a majority of cases, although a radical cure may be difficult or impossible. These cases require to be under constant treatment for long periods, and the very lengthened time, and steady continuous treatment needed for a cure, are probably the main obstacles to that cure. In most cases of chronic granular ophthalmia, attendance three times a week for a year will be required, to effect anything that can be called a cure. The common experience is that patients attend for some weeks, and then, being very considerably relieved of their distressing symptoms, and finding their sight vastly improved, they cease attendance long before the disease has been eliminated, to return after a brief interval with a condition of things as bad, if not worse, than before. It is therefore desirable at the very outset of treatment to explain the tedious and dangerous nature of the ailment to each patient.

Treatment.—The aim of this is to bring about absorption of the trachoma bodies with the greatest possible despatch, in order to prevent the destruction of the mucous membrane to which they tend. No caustic application should be made with the object of directly destroying the trachoma bodies, for this can only be done at the expense of the mucous membrane around them. For chronic cases, with little swelling of the papillæ (blennorrhœa), and with little or no cicatrisation, the best application is the solid sulphate of copper lightly applied to the conjunctiva, especially at its fornix; but when there is considerable papillary swelling, a 2% solution of nitrate of silver, properly neutralised after its application with a solution of salt, or a light application of mitigated lapis, similarly neutralised, is to be preferred. Should there be ulcers on the cornea, or much inflammatory irritation of the eye, sulphate of copper should not be applied to the conjunctiva. An interval of twenty-four hours at least should be allowed to elapse between each application, whether of sulphate of copper or nitrate of silver, and cold sponging for fifteen minutes should be employed immediately after the application. A change of treatment will be occasionally required even if the remedy first used answer well in the beginning, and one or other of the following can be adopted. Pure liquefied carbolic acid has been used with good result, but we have no experience of it. It is applied with a camel's-hair pencil, and the excess washed off with plain water. Solution of Sublimate, 1 in 2000 to 1 in 1000, applied with lint or cotton-wool to the everted conjunctiva with some pressure and rubbing. Liq. plumb. acetatis dil., never to be used except with everted lids, and washed off with plain water by the surgeon; and not even in this way if there be ulcers of the cornea, as the corneal tissue forming the floor of the ulcer is liable to become impregnated with a white deposit, probably the albuminate of lead, which is by no means easy to remove by operation subsequently.

Tannin ointment: Tannin gr. j, to vaseline ʒj, the size of half a pea, to be put into the eye once a day. Sulphate of copper ointment: same strength as the last, and to be used in the same way. Solution of alum: Gr. x to ℥j of distilled water; one drop in the eye once a day. Where an active pannus is present, atropine should be instilled into the eye once a day as a precaution against iritis.

Some employ scarifications of the conjunctiva, when it is much swollen and the papillæ too exuberant; but we have never adopted them, fearing the resulting cicatrices. Brushing of the conjunctiva with a small stiff horsehair brush, or special metallic brush, is a form of scarification used by others, and is sometimes combined with applications of solution of sublimate; and scraping of the conjunctiva with a sharp spoon, with subsequent rubbing in of corrosive sublimate solution, has been recommended.

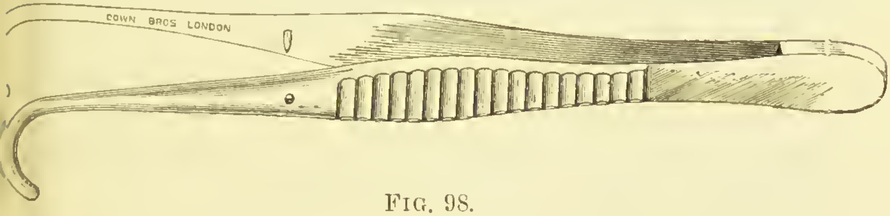

FIG. 98.

Again, it has been proposed to excise or abscise the trachoma bodies; and this may perhaps be allowable if they are isolated and protrude much over the surface of the conjunctiva, but they can be more easily destroyed by a fine electro-cautery.

Squeezing out the granulations between the thumb-nail, used to be practised by the late Sir William Wilde, of Dublin, and has recently again come into use. But the proceeding of 'expression' is nowadays performed by means of an instrument instead of by the finger-nails. The best instrument for the purpose is Grady's trachoma forceps (Fig. 98). The retro-tarsal fold of the everted lower or upper lid is grasped as far back as possible by the instrument, compressed and drawn upon, and in this way the trachomatous tissue is squeezed out with little or no laceration of the conjunctiva. The instrument has to be re-inserted and a neighbouring part of the conjunctiva treated in the same way, and so on, until the whole conjunctiva of each affected eyelid has been operated on. The four eyelids may be manipulated at one sitting, and the evacuation should be so complete that a repetition of the proceeding will not be required. Particular care should be taken to reach the part of the conjunctiva which is hidden under the commissures. Some cases are immediately and permanently cured by this operation; while others, although greatly benefited, will still require a further routine treatment with local remedies. Expression is indicated only where trachomatous substance can be pressed out. Our experience with this method leads us to regard it as a useful one for the acceleration of the cure of some cases of granular ophthalmia before the cicatricial stage has come on.

Excision of the fornix conjunctivæ has been proposed by Schneller, and largely practised by him and other surgeons. It is claimed for this method that it shortens the treatment of all forms of the disease; that, after it, existing corneal processes undergo rapid cure; that the granular disease in the palpebral conjunctiva, although not directly included in the operation, disappears quickly; that recurrences of the disease are rarer than by other plans of treatment; and that the resulting linear cicatrix has no serious consequence, and is as nothing when compared with the extensive cicatricial degeneration of the whole mucous membrane which the operation is calculated to prevent. In order to avoid cicatricial contraction care should be taken during the operation, that sufficient mucous membrane be left to completely cover the globe when the patient looks down. Supplemental treatment with the customary local applications is employed until the cure is obtained. We find that this is a useful procedure in some cases. When the tarsus is much thickened Kuhnt advises a partial or complete excision of it, including the conjunctiva over it, if the latter is diseased.

Infusion of Jequirity (*Abrus precatorius*, Paternoster Bean), long used in the Brazils, was introduced to the notice of European surgeons by de Wecker. The infusion is made by macerating 154 grains of the decorticised jequirity seeds in 16 oz. of cold water (a 3 per cent. infusion) for twenty-four hours. Twice a day for three days the lids are everted, and the infusion thoroughly rubbed into the conjunctiva with a bit of lint. The result is a severe conjunctivitis of a somewhat croupous tendency (even the cornea being often hidden by the false membrane), accompanied by great swelling of the eyelids, much pain, and considerable constitutional disturbance, rapid pulse, and temperature of 100°, or more. At first the pannus becomes more visible, but as the inflammation subsides, it diminishes or even disappears, while complete cure of the granular ophthalmia itself is rarer. Iced compresses to the eyelids may be used during the inflammation. A fresh infusion (not more than seven days old) must be employed in order to secure the best reaction. The majority of surgeons, amongst them the authors, find the remedy harmless, if not always successful; but a good many cases are on record where violent diphtheritic conjunctivitis, followed by blennorrhœa of the conjunctiva, and by more or less extensive ulceration of the cornea, and even complete loss of the eye, were produced. We have, occasionally, seen small superficial ulcers form on the cornea without further injury. De Wecker regards the presence of a purulent discharge from the conjunctiva as a contra-indication for the remedy, which he finds is then liable to increase the intensity of the blennorrhœa in a dangerous degree. Cases where there is little or no papillary swelling, but nearly dry trachoma with pannus, are the most suitable for its use, and we cannot recommend it too highly in these cases. It is marvellous to see the rapid and effective cures of the severest pannus by this remedy in properly selected cases. But the presence of well-marked pannus of the cornea without ulceration is the only thing that can render the employment of jequirity justifiable, and in addition to this the conjunctiva should be free from blennorrhœa.

The occurrence of acute dacryocystitis is said to form an unpleasant complication of the jequirity treatment, even in cases in which the sac was previously quite normal; but we have never seen it to occur.

Of late Jequiritol,[1] which is a sterilised preparation of Abrin, the active principle of jequirity, dissolved in glycerine, and standardized experimentally, has been used. As it is supplied in four different strengths its action can, to a certain extent, be controlled, and if the reaction be too great, Jequiritol-serum can be used to check it, either by simple instillation into the conjunctival sac, or by subcutaneous injection. Although it is safer than jequirity, nevertheless ulcers of the cornea and dacryocystitis have also been observed after its use. We, as well as others, find that strengths number I. and II. produce little or no effect.

After the subsidence of the jequirity inflammation some of the local remedies, above referred to, should be regularly applied for the purpose of completing the cure of the conjunctival condition.

Where pannus is present, an occasional drop of atropine should be instilled, in order to control the tendency to iritis.

Besides local remedies, it is of great importance that the hygienic surroundings of patients suffering from granular ophthalmia be seen to, and that they be obliged to spend a considerable time daily in the open air.

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[1] P. Römer *Von Græfe's Archiv f. Ophth.* lii. The jequiritol and serum can be obtained from E. Merck, Darmstadt. For hospital use it has the disadvantage of being very much more expensive than jequirity.

If the upper lid be tightly pressed on the globe, as it sometimes is, the physiological pressure varying in different individuals, an impediment is offered to the cure by any method, and pannus is promoted. It is then necessary to relieve the pressure by a canthoplastic operation. (See chap. viii.)

The operation of peritomy, which consists in the excision of a portion of the conjunctiva, about 5 mm. broad, around the corneal margin, or destruction of the vessels with the actual cautery, is sometimes useful in the treatment of pannus.

It is too soon yet to gauge the value of treatment by X-rays, high-frequency currents, and radium, which have all been tried with varying results.

Follicular Conjunctivitis.—This variety of conjunctivitis, is characterised by a catarrhal inflammation of a mild type, to which is added the presence in the conjunctiva of small round greyish- or yellowish-pink bodies the size of a pin's head, which disappear completely as the process passes off, leaving the mucous membrane as healthy as they found it. These little bodies are situated chiefly in the lower fornix of the conjunctiva, and may be discovered by eversion of the lower lid, when they will be seen arranged in rows parallel to the margin of the lid. Whether they are easily discovered or not depends on their size and number, and on the amount of co-existing hyperæmia or chemosis of the conjunctiva. The structure of these bodies shows them to be lymph follicles.

Follicular conjunctivitis usually attacks both eyes, and is a very tedious affection, lasting often for months. It is chiefly met with in children and most frequently in schools. Systematic examinations of the conjunctiva in schools have shown that a very large number of the children have follicles in the lower fornix, and occasionally they may be seen in the upper lids towards the angles. In some cases post-nasal adenoids are associated with them. The conjunctiva is otherwise normal and the follicles produce no irritation or distress of any kind. To this condition the name "Folliculosis" is sometimes given, and it is believed that it renders the eye more liable to catarrhal infection. When this occurs, follicular conjunctivitis is the result.

The existence of lymph follicles in the normal conjunctiva is disputed, and it is of course possible that in cases in which they are found, their presence may be explained by the repeated but transient irritation, to which the conjunctiva, from its exposed position, is constantly liable.

Considerable difference of opinion prevails as to the relation of this disease to trachoma, some believing that it is merely a mild or abortive form of the latter. The question cannot be definitely settled until we know the real nature and cause of these affections. Clinically they seem to be distinct, and from our observation in this country, where both are very common, there are no practical reasons for regarding them as different forms of the same disease. The chief points of difference are these:—Follicular conjunctivitis affects children, even in upper-class schools; trachoma occurs at all ages, but mostly in adults, and is confined to the lower classes. In follicular conjunctivitis the follicles are, with rare exceptions, confined to the lower lid; they are more uniform in size and more regular in their arrangement than in trachoma; furthermore they never produce cicatrices, pannus, or any of the ill effects which follow trachoma.

The Symptoms are much the same as those of catarrhal conjunctivitis. Frequently there is little or no injection of the bulbar conjunctiva, and the chief symptom is asthenopia—an inability to continue near work for any length of time—and much distress in artificial light.

Causes.—These are much the same as in simple catarrhal conjunctivitis. The long-continued use either of atropine or of eserine is liable to bring on the disease.

Treatment.—The most useful remedy in this troublesome affection is an ointment of sulphate of copper of from gr. ss. to gr. ij in ʒj of vaseline. The weaker ointments should be used at first, and later on the stronger ones if it be found that the eye can bear them. The size of half a pea of the ointment is inserted into the conjunctival sac with a camel's-hair pencil once a day. Eye-drops of equal parts of tincture of opium and distilled water are of use in some cases. Abundance of fresh air, with change from a damp climate or neighbourhood to a dry one, is of importance. If the use of a solution of atropine have induced the disease, it should be discontinued; and if a mydriatic be still required, a solution of extract of belladonna (gr. viij ad ℥j) may be employed in its stead.

In cases of pure folliculosis no local treatment is required. It may be well to add that no alarm should be created in a school on account of the occurrence of follicular conjunctivitis. The utmost that might be necessary would be the separation of those cases in which there was much discharge, which might spread the catarrhal inflammation.

***Parinaud's Conjunctivitis.**—This is a well-defined form of subacute conjunctivitis which attacks only one eye. It was first described by Parinaud in 1889.[1] The chief features of the disease are: The appearance of granulations or vegetations on the tarsal conjunctiva or fornices, with painful and considerable enlargement of the preauricular and neighbouring glands, on the same side as the affected eye; the disease is ushered in with chills and malaise; there is slight mucous, or fibrinous, secretion but no suppuration; a complete cure results in the course of some months, without any corneal complication or subsequent scarring.

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[1] Société d'Ophthalmologie de Paris, 5 février.

The upper lids become swollen and perhaps nodular to the touch; there is sometimes chemosis, but the subjective symptoms are slight. The granulations are red or yellowish, at first semi-transparent, and vary in size, being at times only as large as the head of a pin, while at others they may even form polypoid growths. Small yellow granules and superficial erosions are also often present, generally in the furrows between the large granulations. The glandular inflammation sets in along with, or immediately after the eye symptoms, and may end in suppuration. The submaxillary and sometimes even the cervical glands are affected. The last symptoms to disappear are ptosis and some amount of glandular enlargement.

Cause.—Up to the present the cause is unknown, and no case of the communication of the disease to others has been observed. The theory of an animal origin, which was originally advanced, has not been proved. The histological changes according to Verhoeff and Derby,[1] consist in areas of necrosis in the subconjunctival tissue and extensive infiltration with lymphocytes and phagocytes, but no suppuration. The deeper layers are in a state of chronic inflammatory reaction. Hoor,[2] on the other hand, found that the nodules exhibited a tubercular structure, but failed to obtain any evidence of their tubercular nature. The only affections with which this disease is liable to be confounded, are trachoma and tuberculosis, from which it can be distinguished by its symptoms and course, as well as by bacteriological methods of examination.

Treatment.—Simple antiseptic treatment is almost sufficient, but the duration of the disease may be shortened by excision of large granulations, or galvanocautery, and incision of the glands if they suppurate.

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[1] *Archives of Ophth.* (1904), xxxiii., p. 389, and *Klin. Monatsbl.*, xliii. (1905), p. 705.

[2] *Klin. Monatsbl.*, 1906, p. 289.

***Tubercular Disease of the Conjunctiva.**—This disease usually commences in the palpebral conjunctiva of the upper lid or in the upper fornix, and very rarely on the bulbar conjunctiva, in the form of a caseating ulcer, or as an inflammatory new formation of the granuloma type, and is nearly always unilateral. The granular form occurs in the shape of small yellow or grey subconjunctival nodules, resembling miliary tubercles, or may result in the development of flattened outgrowths, cockscomb-like excrescences, or even pedunculated tumours. The margins of the ulcers are well defined, and their floors either of a yellowish lardaceous appearance, or covered with greyish-red granulations. The surrounding conjunctiva is swollen, and if the palpebral conjunctiva be much involved the lid becomes enlarged in every dimension, and the ulcerative process may soon destroy part of the lid. It may also extend to the bulbar conjunctiva, and the cornea may become covered with pannus. The preauricular and submaxillary glands usually become enlarged. The positive diagnosis of the nature of the disease can only be made by the discovery of the characteristic tubercle bacillus, which will distinguish this from secondary syphilitic ulceration of the conjunctiva, between which and the tubercular ulceration there is sometimes a resemblance. The appearance may sometimes be suggestive of trachoma, or even of a malignant growth. As it not infrequently happens that the bacilli elude detection owing to their scarcity, and that excised portions of the growths do not always show a typical tubercular structure, inoculation experiments may be necessary to remove all doubt. Tubercular conjunctival disease is usually unattended by pain, or there is only a slight burning sensation ; but, again, when the ulceration is extensive, severe pain may set in.

The disease is very chronic, its progress sometimes extending over many years. It is rarely met with except in youth. Some of those whose eyes are attacked are already the subjects of tuberculosis in other organs, but very many of them are perfectly healthy in that respect. In fact, we have reason to believe that tuberculosis of the conjunctiva is much more often a primary disease, the result of an ectogenic infection, even in cases where already tuberculosis exists elsewhere, than of infection occurring through the blood. Tubercle bacilli introduced into the normal conjunctival sac have, it is true, been found to be harmless, for the intact epithelium offers an insuperable obstacle to their entrance into the tissue. But a superficial loss of substance of the conjunctiva is sufficient to allow of its inoculation with the bacilli, and then the disease becomes established. The frequent lodgment of foreign bodies under the upper lid explains why this is the most common place for the disease to begin. But although conjunctival tubercular disease is not often secondary to tubercular disease in other parts of the system, yet it is itself liable to be the starting-point of general tuberculosis.

Treatment.—The fact last mentioned makes it most important, in cases of primary tubercular disease of the conjunctiva, to thoroughly eradicate the diseased focus so as to avert an infection of other organs, and this can often be effected. If the ulcers be not already too extensive they must be scraped, and the actual cautery freely applied to them. And they may be then dusted with iodoform. Injections of tuberculin are also useful (see chap. vii.). Where the disease has already spread to the cornea, sclerotic, iris, or chorioid, enucleation of the eyeball is imperatively called for.

***Ophthalmia Nodosa.**—This disease is caused by the irritation (chemical or mechanical) of the hairs of certain kinds of caterpillars. The hairs give rise to 'foreign body' granulomata, which appear as small nodules chiefly on the lower part of the bulbar conjunctiva. Both clinically and microscopically the condition bears a resemblance to tuberculosis, hence it has also been called pseudo-tubercular conjunctivitis. The presence of the hairs makes the diagnosis positive. In nearly all cases there was a history of caterpillars having accidentally come into forcible contact with the eye. The nodules are small semitranslucent and reddish or yellowish grey in colour. The disease is chronic, as the elimination or absorption of the hairs takes some time, but it terminates in complete recovery, unless the hairs have made their way into the iris, in which case a severe iridocyclitis may be set up.

***Lupus** of the conjunctiva usually occurs as an extension of the disease from the surrounding skin, or rarely from the lacrimal sac, as in a case in the 'Mater' Hospital, where the disease extended from the mucous membrane of the nose, through both lacrimal sacs, to the inferior palpebral conjunctiva. It is seen as a patch or patches of ulceration, covered with small dark-red protuberances or granulations, chiefly on the palpebral conjunctiva, which bleed easily on being touched.

Like lupus of the skin, these ulcerations undergo spontaneous healing and cicatrisation in one place (unlike tubercular ulceration in that respect), while they are still creeping over the surface in another direction. But we now know that lupus, wherever it occurs, is really a tubercular disease, and that the two forms differ only in their clinical aspect.

The Treatment is scraping with a sharp spoon and the application of the actual cautery. Iodoform. Tuberculin. X rays.

***Syphilitic Disease of the Conjunctiva** occurs both as primary and as secondary disease. It will be treated of n chap. viii., on Diseases of the Eyelids.

Ulcers of the Conjunctiva.—In addition to tubercular and syphilitic ulcers the following conditions may lead to ulceration of the conjunctiva:—Injuries, foreign bodies, the separation of sloughs or membranes, pemphigus, epithelioma, smallpox; phlyctens also appear as small superficial ulcers on the bulbar conjunctiva at one stage of their existence.

***Spring Catarrh, or Vernal Conjunctivitis.**—The tarsal conjunctiva of the upper lid is invaded by hard flattened bodies of a pale pinkish colour arranged close together, and known as tesselated or pavement granulations (Fig. 99). They are slightly pedunculated. The conjunctiva assumes a milky-white opacity. The bulbar conjunctiva becomes injected, slightly œdematous, and at the limbus somewhat elevated with hard, gelatinous-looking and nodular greyish swellings. The lower palpebral conjunctiva is often milky-looking, but never shows granulations. All these appearances may be present in the same case, or any one (the bulbar appearances, or the pavement granulations, or the milky-white opacity) or two of them may be absent. The margin of the cornea itself is apt to be invaded (Fig. 100) with a more or less circular infiltration resembling arcus senilis. Very occasionally the cornea becomes seriously

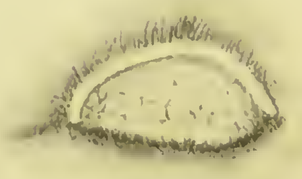

FIG. 99.—Spring catarrh. Upper lid everted.
From sketch by L.W.

complicated by the growth on the limbus extending over a great portion, or even the entire cornea. There is some mucous or muco-purulent secretion, and the patient complains of the eyelids being stuck together in the morning, of difficulty of using the eyes for near work, of itching and burning sensations, and all these symptoms are increased by exposure to heat. The eyelids droop slightly, giving the patient a sleepy look.

Strictly speaking the disease is not a catarrh. The condition of the upper lid might at first suggest granular ophthalmia.

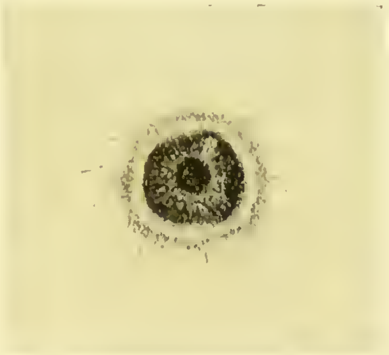

FIG. 100.—Circumcorneal growth in spring catarrh. Sketched by L. W.

The pathological changes consist in hypertrophy of the subconjunctival tissue, especially of the elastic fibres,[1] and proliferation of the epithelium which sends solid or cystic processes into the stroma. It is still uncertain which of these is the primary change. The affection is chiefly met with in boys between six years of age and puberty, and s mostly bilateral.

It makes its appearance with the advent of warm weather n the late spring or early summer, and generally disppears, or is much modified in the cool seasons, to return gain with the next warm season, and this is liable to go on for a long series of years. In the intervals between the attacks the congestion and subjective symptoms disappear, but the other appearances persist until the recovery sets in.

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[1] Schick, *Von Graefe's Archiv f. Ophth.*, xlviii. 1.

The Treatment of the majority of these cases yields very unsatisfactory results. Protection glasses should be worn. So far as possible all exposure to great heat of sun or artificial heat should be avoided. If possible the patients should reside in a cool place in the summer. Weak astringent collyria, or ointments, may be used; or iodoform ointment (1 in 15), a little put into the eye once a day; or massage twice daily in conjunction with yellow oxide ointment. Dilute acetic acid 1 or 2m. to the ℥j is also recommended. De Schweinitz recommends boroglyceride locally, and arsenic internally. Antipyrin and quinine internally have proved of use in some cases. For the tarsal granulations Theobald has found marked benefit from use of the roller forceps. Strong salicylic acid ointment (20 grs.—℥j) has been recommended, but it was tried in a couple of cases in the 'Mater' without much effect. Adrenalin drops have proved very beneficial in some cases.

***Conjunctival Complication of Smallpox.**—Of this we have, fortunately, no experience. The following embodies the views of the late Professor Horner, who studied the subject during an epidemic. A good deal of uncertainty prevailed previously, for the initial stages of the eye affection were not carefully observed by physicians, owing to the swelling of the eyelids, while the ophthalmologist saw only the results of the process in the period of convalescence.

Smallpox pustules on the cornea are, Horner believed, extremely rare; indeed, he saw but one such case. The most frequent and most serious mode of attack consists in a greyish-yellow infiltration in the conjunctiva close to the lower margin of the cornea, not extending to the fornix conjunctivæ, nor far along the inner or outer margin of the cornea. It occurs in the eruptive stage, and is to be regarded clinically as a variola pustule. This infiltration or pustule gives rise to a corneal affection, as does a solitary marginal phlyctenula, either in the form of a marginal ulcer or as a deep purulent infiltration, ulcerating, perforating, leading to staphyloma, purulent irido-chorioiditis and panophthalmitis—results which are often first observed long after the primary conjunctival affection has disappeared.

Horner believed that the germ of the conjunctival infiltration makes its way between the eyelids, and that the constancy of the position of the infiltration below the cornea is accounted for by this theory, that part of the conjunctiva, with closed eyelids and eyeball consequently rotated upwards, being the most exposed to particles entering.

Treatment.—On this ground he recommended the prophylactic use of boracic acid ointment on lint applied over the eyelids. If a conjunctival pustule have already formed without any, or only commencing, corneal affection, he would destroy the pustule with fresh chlorine water, or with mitigated lapis carefully neutralised. Corneal complications are treated as in blennorrhœa of the conjunctiva or diphtheritis.

The frequency with which the eyes become affected varies n different epidemics.

As true post-variolous eye-affections, Horner recognised diffuse keratitis, iritis, and irido-cyclitis, with opacities in the vitreous humour, and glaucoma; in the hæmorrhagic form of the disease, hæmorrhages in the conjunctiva and retina; and, where pyæmic poisoning comes on, septic affections of the chorioid and of the retina take place.

***Hyaline, Colloid, and Amyloid Degeneration.**—This very rare disease is a primary affection of the conjunctiva and is not associated with amyloid disease in any other part of the system. It has been found combined with granular phthalmia, but this was most likely due to a fortuitous oincidence of the two diseases. It is most frequently met with in patients between twenty and twenty-five years of age, generally in one eye only, and is extremely chronic, lasting for years. The retro-tarsal folds and palpebral conjunctiva are chiefly attacked, but it may also involve the bulbar portion. It causes great tumefaction of the affected lid, without any inflammatory symptoms. The eyelid can be but partially elevated, and is often so stiff and hard that it can be everted only with difficulty. The conjunctiva is yellowish, wax like, non-vascular and friable. The disease ultimately extends to the tarsus.

Microscopically, homogeneous masses are found in the conjunctiva, with variable staining properties, according to which they are called Amyloid, Hyaline, or Colloid. Calcification occurs in the later stages. Ræhlmann believes that the amyloid changes are always preceded by lymphoid infiltration. Figs. 101 and 102 are from a case in the 'Mater' hospital which presented the clinical appearance of amyloid diseases with the histological structure of a purely lymphoid thickening.

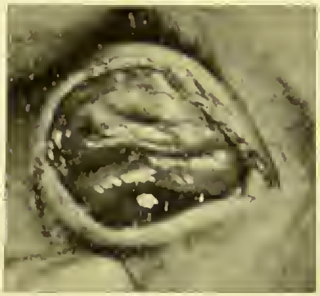

Fig 101.—Lymphoma of conjunctiva.

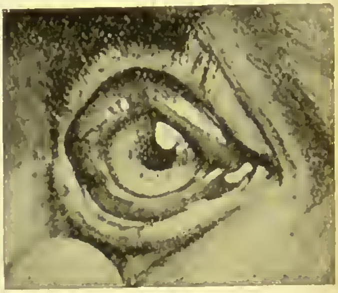

Fig. 102.—Same case as fig. 101.

Treatment.—A partial removal of the diseased parts by the knife or scraping, is all that is necessary, as the remainder disappears spontaneously, and further excessive scarring is thus avoided. A very good result was obtained in the above case by this method.

*__Xerosis__ (ξηρός, *dry*), or **Xerophthalmos,** is a dry, lustreless condition of the conjunctiva, associated in the severer forms with shrinking of the membrane. There are two forms of the affection—the parenchymatous, which is a local affection, and the epithelial, associated with general malnutrition.

In Parenchymatous Xerophthalmos there is a more or less extensive cicatricial degeneration of the conjunctiva, dependent upon changes in its deeper layers, while its surface and that of the cornea become dry, and the latter becomes opaque, and the eye consequently sightless. The conjunctiva shrinks so completely, in many of these cases, that both lids are found adherent in their whole extent to the eyeball, which is exposed merely at the palpebral fissure, where the opaque and lustreless cornea is to be seen. From what remains of the conjunctiva, scales, composed of dry epithe-ium, fat, etc., peel away. The motions of the eyeball are restricted in proportion to the extent of the conjunctival degeneration. There is no cure for this condition.

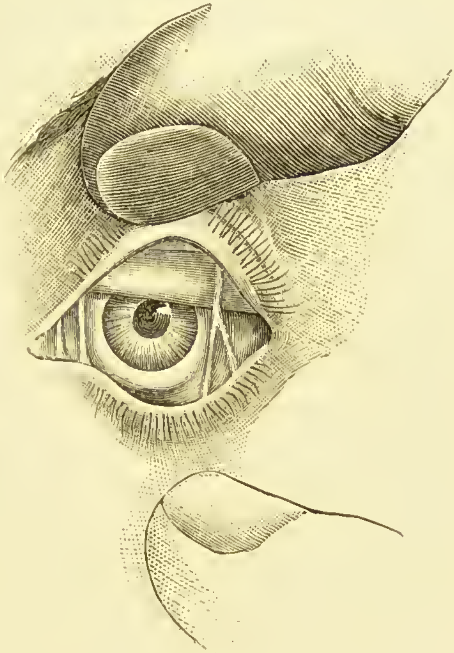

FIG. 103.

Fig. 103 represents a case of xerophthalmos, the result of pemphigus, which occurred in a patient at the Royal Victoria Eye and Ear Hospital. Here the eyelids were not wholly adherent to the eyeball, and the cornea remained clear.

The Causes of parenchymatous xerosis of the conjunctiva are granular ophthalmia, diphtheritic ophthalmia, pemphigus, burns, and the condition is said to be very occasionally seen as a primary disease, described as essential shrinking of the conjunctiva. Many observers altogether deny the existence of this primary disease, and maintain that the cases described as being of that nature are merely the result of pemphigus, and we are inclined to agree with this view.

Treatment.—As cure is impossible in this form of xerophthalmos, the only indication is to afford relief, so far as it can be done, from the distressing sensations of dryness of the eyes which are complained of. The best applications are milk, glycerine, olive oil, and weak alkaline solutions, and the eyes should be protected from all irritating influences by protection goggles. Transplantation of mucous membrane, or temporary union of the lids as a rule only produce a transient improvement.

Epithelial Xerosis of the conjunctiva is confined to the epithelium of that part of the conjunctiva which covers the exposed portion of the sclerotic in the palpebral opening. It there becomes dry and dull and covered with a white foam due to altered Meibomian secretion. The xerotic patches, which are triangular in shape, with the base at the corneal margin, are known as Bitot's Spots. The whole bulbar conjunctiva is loose, and easily thrown into folds by motions of the eyeball, and there may be a good deal of secretion. This form of xerophthalmos often occurs in epidemics, but also sporadically, accompanied by night-blindness (the light-sense unimpaired) and contraction of the field of vision. The combined condition has been noticed chiefly in persons of debilitated constitution, who have been exposed to strong glares of light, and is said to have appeared in epidemics, under these conditions, in foreign prisons and barracks. Epidemics have been chiefly seen in Russia, especially during the Lenten fasts.

The dryness of the conjunctiva is due to cornification of the epithelium, which the tears cannot properly moisten. Xerosis bacilli are found in large numbers, but are not the cause of the disease.

Treatment by rest, protection from glare of light, nutritious diet, and tonics, especially cod liver oil, invariably restore the eyes to their normal functions.

Again, epithelial xerosis occurs in very young cachectic children, in connection with a destructive ulceration of the cornea (see Keratomalacia, chap. vii.).

***Pemphigus of the Conjunctiva.**—This is another rare disease. It has been seen in connection with pemphigus vulgaris of other parts of the body, but it also occurs as an independent disease. It is attended by attacks of much pain, photophobia, and lacrimation; and the conjunctiva, at each place where subconjunctival exudation of serum has been situated, undergoes degeneration and cicatricial contraction. Such attacks succeed each other at shorter or longer intervals, for weeks, months, or years, until, finally, the entire conjunctiva of each eye may have become destroyed, and the eyelids are adherent to the eyeball. The cornea gradually becomes completely opaque, or, having ulcerated, becomes staphylomatous. In the course of the disease the eyelashes are apt to become turned in on the eyeball, or even entropion may form; and these conditions aggravate the suffering of the patient.

The foregoing is a description of a severe case. In less severe cases the conjunctiva may not be completely destroyed, and the cornea may not be affected.

Bullæ are seldom seen, for the conjunctival epithelium is so delicate that the serous exudation beneath it breaks it down at once. Consequently, the conjunctival surface is found in these cases to be covered by what looks like a membranous deposit, upon removal of which a raw surface is exposed; and these appearances have led to the mistaken diagnoses of croupous and of diphtheritic conjunctivitis. Rarely deep-seated bluish cysts are present. They existed in the case illustrated by Fig. 103.

Treatment is helpless in respect of arresting the progress of the disease, or of restoring sight when lost in consequence of it. The most one can do is to relieve the distressing symptoms by emollients to the conjunctiva, and by the use of closely fitting goggles, to protect from wind, dust, and sun. Internally, arsenic is indicated.

Pinguecula (pinguis, *fat*) is the name given to a small yellowish elevation on the exposed part of the bulbar conjunctiva near the margin of the cornea, usually at its inner side, more rarely at its temporal margin, but sometimes in each place. It is most commonly seen in old people as a triangular patch or rounded tumour. Notwithstanding its name, it contains no fat, but is composed of connective tissue, hyaline deposits, and elastic fibres. It is supposed to be due to the irritation caused by small foreign bodies. It rarely grows to a large size, and requires no treatment unless it become very disfiguring, when it may be removed with forceps and scissors. When an eye becomes congested or ecchymosed, the pinguecula, if present, stands out as a white or yellow patch and may lead in some cases to mistakes in diagnosis.

Pterygium (*πτέρυξ, a wing*).—This is a vascularised thickening of the conjunctiva, triangular in shape, situated most usually to the inside of the cornea, sometimes to its outer side, but never above or below it. The upper and lower margins of the triangle are limited by a shallow depression or fold. The blunt apex of the triangle, or head of the pterygium, is on the cornea; and its base, the body, at the semi-lunar fold. The neck of the pterygium is that part of it at the margin of the cornea. There is frequently, but not always, a tendency of the growth to advance into the cornea, of which it seldom reaches the centre, and still more rarely extends quite across it.

In its early growth the pterygium is somewhat thick and succulent-looking, and very vascular; but finally it ceases to grow, and then becomes thin and pale, and this is its retrogressive stage; yet it never entirely disappears. Sight is not affected unless the pterygium extends over the pupillary region of the cornea. A limitation of the motion of the eye to the other side, and consequent diplopia, is sometimes caused by a pterygium; but, for the most part, the disfigurement alone it is which brings these cases to the surgeon.

Cause.—It was formerly believed that the starting-point of a pterygium was an ulcer at the margin of the cornea, which in healing caught a morsel of the limbus conjunctivæ and drew it towards the cicatrix, throwing the mucous membrane into a triangular fold. But ulcers are never found at the apex of a true pterygium, and the condition brought about in this manner is known as pseudopterygium and differs in many ways from true pterygium. The false pterygium may occur at any part of the circumference of the cornea. It is very variable in shape, is non-progressive, and in most cases a fine probe can be passed under the neck of the growth where it bridges over the limbus. Again in a false pterygium a nebula or leucoma is frequently found at the apex.

Fuchs believes that pterygium develops from the pinguecula, and that the latter causes nutritive changes in the cornea, loosening the superficial lamellæ, and allowing the connective tissue of the limbus to grow in on the cornea.

Pterygium is a rare affection in this country, but is more common in countries or localities where the air is filled with fine sand or other minute particles.

Treatment.—Unless the pterygium be very thick, and have invaded the cornea to some extent, or be progressing over the cornea, it is well to let it alone; the more so as by removing it a quite normal appearance is not given to the eye, for a mark is necessarily left both on cornea and conjunctiva. If it be progressive or very disfiguring, it should be removed, other proposed modes of dealing with it being futile. This may be effected either by ligature or excision.

In the method by ligature a strong silk suture is passed through two needles. The pterygium being raised with a forceps close to the cornea, one needle is passed under it here and the other needle in the same way close to its base, the ligature being drawn half-way through. The thread is cut close behind each needle, thus forming three ligatures, which are respectively tied tight. In four or five days the pterygium comes away.

For excision the apex is seized with a forceps and dissected off either with a scissors or fine scalpel, care being taken not to injure the true cornea; or a good plan is to pass a strabismus hook under the pterygium when raised up from the sclerotic, and to forcibly separate the corneal portion by drawing the hook under it. The dissection is continued towards the base of the pterygium, where it is finished with two convergent incisions meeting at the base. The mucous membrane in the neighbourhood of the base is separated up somewhat from the sclerotic, and the margins of the conjunctival wound are then carefully brought together with sutures. Skin grafts, according to Thiersch's method, have been used with success to cover the defect.

***Lithiasis** consists in the calcification of the secretion of the Meibomian glands, which are seen as small white or yellowish spots not larger than a pin's head in the conjunctiva. There may be one only or very many. Concretions similar to these but more superficial also occur in the lower fornix; they are found in the interior of newly formed glands which have become cystic. These concretions often give rise to much conjunctival irritation, and if they protrude over the surface of the conjunctiva may injure the cornea. Each one—the eye having been cocainised—must be separately removed by a needle, with which first an incision has been made into the conjunctiva over the concretion.

Uric acid deposits have been observed in the palpebral conjunctiva in gouty patients.

***Conjunctivitis Petrificans.**—Under this title Leber has described a rare and remarkable disease of the conjunctiva. In the course of a brief period, and accompanied by some slight inflammatory reaction, a stony hard, white, chalky substance is deposited, in more or less extensive patches, in the previously healthy conjunctiva, the deposit being scarcely raised over the conjunctival surface. The disease attacks a part of the bulbar or palpebral conjunctiva, and may extend to the intermarginal portion of the eyelid. One or both eyes may be attacked. After a time, which varies from a week to several months, the deposit is thrown off or absorbed, and the affected part suffers either no detriment or there may be slight thickening and shrinking. There is no great tendency to corneal complications, but slight marginal ulcerations, which heal readily, occasionally occur. In one case severe diffuse opacity of the cornea seriously affected the sight. Frequent relapses are liable to take place in the same or in different parts of the conjunctiva, and the whole course of the affection may extend over several years, and then end in complete cure.

No cause has as yet been assigned for this disease, although Leber suspects it to be an ectogenic microbic infection. The only treatment which seems to be of use is warm fomentations, and the careful operative removal from time to time of the chalky scales as they become loosened from the main mass.

Subconjunctival Ecchymosis.—The rupture of a small subconjunctival vessel in the bulbar conjunctiva, without conjunctivitis, is of frequent occurrence. It suddenly gives a more or less extensive purple hue to the 'white of the eye,' causing the patient much concern. It is common enough in old people, but may occur in the young, and even in children, from severe straining, as in hooping-cough, vomiting, or raising heavy weights. It is occasionally significant of diabetes. It also occurs sometimes during epileptic fits, and profuse subconjunctival hæmorrhage is occasionally found in cases of fracture of the base of the skull, having made its way along the floor of the orbit. It is of no importance so far as the integrity of the eye is concerned.

Treatment.—The extravasated blood becomes absorbed without treatment, but dionine may accelerate the process.

Subconjunctival Serous Effusion. Chemosis.—This has been previously alluded to in connection with some forms of conjunctivitis, but it may appear in inflammatory affections of the neighbouring parts (orbit, lacrimal sac, eyelids). A stye for instance is sometimes accompanied by well-marked chemosis. Dionine also produces a serous exudation which is preceded, however, by an initial stage of congestion. In Bright's disease a slight degree of chemosis often occurs.

Treatment.—As a rule no special treatment is required beyond that of the disease of which it forms a symptom, but if it be excessive the conjunctiva may be snipped with a scissors, with very good effect.

Injuries of the Conjunctiva.—Foreign bodies frequently make their way into the conjunctival sac, and cause much pain, especially if they get under the upper lid, by reason, chiefly, of their coming in contact with the corneal surface during motions of the lid and of the eye. If the foreign body be under the lower lid it will be easily found on drawing down the latter, and, provided it be not actually embedded in the mucous membrane, which is a rare occurrence in the lower lid, it is easily removed with a camel's-hair pencil or with the corner of a soft pocket-handkerchief; but if the foreign body be under the upper lid it is necessary to evert the latter before it is reached. Should the foreign body be embedded in the conjunctiva it must be pricked out of its position with the point of a needle or other suitable instrument.

Large foreign bodies, such as a grain of wheat, may lie hidden in the upper fornix for several weeks. We have seen ulceration of the cornea caused in this way, and also cockscomb-like granulations in the fornix.

The conjunctiva is frequently injured in severe wounds of the eyelids or eyeball. The interest and treatment are centred here chiefly on the other more important parts, which have been injured. A tear or wound of the conjunctiva (usually of the bulbar portion), when it occasionally occurs without injury to other parts, is in general of very slight moment. If the wound be extensive its edges should be drawn together with a few points of suture; but otherwise healing will take place with the aid simply of a bandage to keep the eye closed for a few days.

A common form of injury, which may involve the conjunctiva alone, is a burn by acid or lime. In the case of a strong acid getting into the eye, if the patient be seen immediately after the occurrence, the whole conjunctival sac should be well washed out with an alkaline solution (1 per cent. soda solution). In the case of lime, after all the larger particles have been most carefully removed from the eye with forceps, a weak solution of a mineral acid may be used for washing out the conjunctival sac; or, as is recommended by some, a solution of sugar as thick as syrup may be poured into the eye. Later, olive or castor oil, or even butter, may be applied, the subsequent treatment being continued with weak sublimate ointment. Cocaine may be employed to relieve the pain. But even in the case of unslaked lime the conjunctiva may be washed with plain water, provided plenty be used and that the operation be done quickly. The heat generated by the slaking of the lime is developed slowly, and further it is the chemical action rather than the heat which is injurious.

In the case of a severe burn of the conjunctiva, the resulting cicatrix is liable to produce a more or less extensive union of the eyelid to the eyeball (Symblepharon), which often interferes with the motion of the latter, or even with vision, if the cornea be obscured. No measures taken during the healing process can prevent symblepharon if the degree of the burn be such as to bring it about. The relief of symblepharon by operation will be dealt with in chap. viii., on Diseases of the Eyelids.

CYSTS.

***Simple Cysts** of the conjunctiva are very rare. They appear as clear spherical protuberances of about the size of a pea, seated usually on the bulbar conjunctiva. The walls of the cysts contain but few vessels, are thin, and almost transparent; while for contents they have a clear limpid fluid. These cysts cannot as a rule be moved from their position, because they are adherent to the conjunctiva, which indeed takes part in the formation of their walls. The majority are dilated *lymphatic* vessels, as shown by their endothelial lining. Small beadlike strings of dilated lymphatics are very frequently seen on the bulbar conjunctiva. *Retention cysts* are also developed in Henle's and Krause's glands, as well as in the so-called glands resulting from chronic inflammatory conditions. *Implantation cysts*, due to proliferation of included surface epithelium, occur as the result of injury, and *congenital cysts* are also met with.

Treatment.—The cyst may be dissected out, or it may be sufficient to abscise its anterior wall, and scrape or cauterise the interior.

***Subconjunctival Cysticercus** is a little more common than simple cyst of the conjunctiva, and yet only about fifty-five examples of it have been recorded.

Cysticercus is distinguished from simple cyst by its free mobility under the conjunctiva, to which it is not attached; by its thicker and more vascular walls; and, above all, by the presence of a round, white, opaque spot on the anterior surface, first pointed out by Sichel, and looked on by him as pathognomonic of a cysticercus. This spot indicates the position of the receptaculum; and occasionally, when this comes to be placed on the posterior surface of the cyst, it may be difficult, or impossible, to make the diagnosis with certainty, but in doubtful cases the character of the hooklets and the tuberculated cyst-wall will solve the question after excision.

Treatment.—The cyst may be pushed to one side under the conjunctiva, an incision made in the latter, the cyst then pushed back again, and dissected out through the opening.

TUMOURS.

Solid tumours of the conjunctiva may be divided into congenital (Dermoid, Lipoma, Nævus) and acquired. The latter are benign (Papilloma, Angioma, Lymphoma, etc.) or malignant (Epithelioma, Sarcoma).

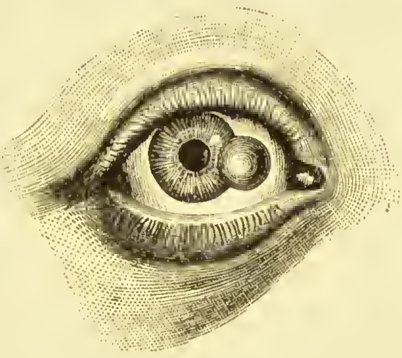

FIG. 104.

***Dermoid Tumours.**—These are pale yellow or white in colour, and in size from that of a split pea to that of a cherry. They are smooth on the surface, dry looking, and sometimes have fine hairs, and sit usually at the outer and lower margin of the cornea; but in the case llustrated by Fig. 104 it was ituated on the inner side of the cornea, extending over somewhat on the latter, and not at the most usual seat. n structure they resemble that of the skin.

They often increase in size at puberty, and the hairs then grow. They are congenital tumours, supposed to be due to an arrest in development, but they often have a tendency to extend over the cornea. If this tendency be present, the tumour must be removed by dissecting it off the cornea, care being taken not to go into the deep layers of the latter.

***Dermo-Lipoma** occurs as a fibro-fatty congenital tumour, usually situated between the superior and external recti muscles. Pure lipoma is exceeding rare. Fig. 105 represents a dermo-lipoma in an unusual situation. The patient sought relief on account of the irritation caused by the long hairs which were only noticed about puberty.

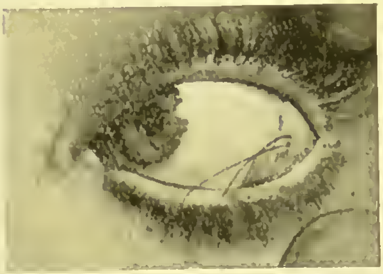

Fig. 105.—Dermo-lipoma with hairs.

Osteoma is a very rare congenital tumour, which occurs in the same situation as the dermo-lipoma.

***Nævus (or Mole).**—This congenital usually pigmented growth appears most commonly at the limbus, as a brown spot, or as a flat gelatinous looking swelling, of a brown or reddish colour. It may be stationary, or may become progressive at puberty. The pigmented variety occasionally forms the starting point of a pigmented sarcoma. Microscopically a conjunctival nævus consists of epithelial downgrowths combined with groups of smaller so-called nævus cells, the origin of which is doubtful. Cases which have been described as benign epithelioma and dermo-epithelioma were most probably unpigmented nævi.

Treatment.—If the nævus be disfiguring or progressive it can easily be excised.

***Hæmangioma (Vascular Nævus).**—This is generally met with in young people and is often congenital, but is sometimes the result of injury. It may be capillary or cavernous and is liable to increase in size. It occurs along with the same condition of the lids, but also separately, especially on the plica or caruncle.

Treatment.—Electrolysis or ligature. Good results have been obtained by Snell with ethylate of sodium carefully painted on.

***Polypus and Granuloma.**—True mucous polypi never occur on the conjunctiva. The growths, to which the name of polypus is given, are tumours of different kinds which become pediculated owing to the movements of the lids and eyes; they are fibromata or papillomata. Granulomata, or granulation tissue, occurring after operations (squint, enucleation, chalazion) or produced by foreign bodies, or even tuberculosis, may also assume a polypoid form. The soft fibromata are sometimes the cause of bloody tears.

***Lymphoma.**—Diffuse lymphoma of the conjunctiva occurs in leukæmia or pseudo-leukæmia, but also as a primary affection, which is probably an early stage of amyloid disease (see Figs. 101 and 102).[1] Small lymphomatous or lymphosarcomatous tumours are met with rarely, chiefly at the inner canthus. Some of the cases described as lymphoma were examples of Parinaud's disease.

***Papilloma,** or **Papillary Fibroma.**—This is a non-malignant growth, which may spring from any part of the conjunctival sac. It may occur at any age, and several tumours may be present. It is much more common in men than in women. It appears in the beginning as a small round red knob. The papillomata growing from the tarsal conjunctiva and from the semi-lunar fold frequently take on a cauliflower appearance; while on the bulbar conjunctiva and in the fornix the growths are liable to be pedunculated, with a papillary surface. The limbus of the conjunctiva is a favourite seat for a papilloma (Fig. 106,) and in the early stage it may be impossible to distinguish it from an epithelioma. But at a later stage, when the growth has overlapped the cornea, the papilloma merely overlies it and can be lifted freely off it with a probe, while the epithelioma, as a rule, infiltrates the corneal tissue. Moreover, enlargement of the pre-auricular gland only occurs in the latter. But it must be remembered that papillomata in elderly people sometimes become malignant.

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[1] *Trans. Oph. Soc. U. K.*, xxiv., p. 24.

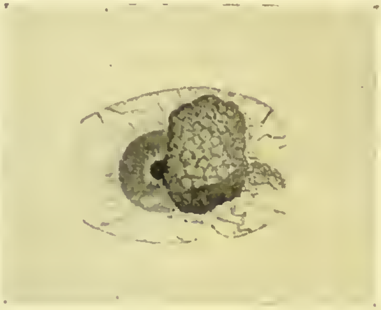

FIG. 106.—Papilloma growing at the limbus.
Sketched by L. W.

Treatment.—Thorough removal with knife or scissors, followed by the use of actual cautery, as otherwise the growth is liable to recur.

***Malignant Tumours (Epithelioma, Sarcoma).**—These rare growths generally take their origin in the limbus, most frequently at the temporal side. They are often extremely slow in their growth, lasting perhaps several years before attaining any considerable size. They are epibulbar tumours, that is to say they spread on the surface of the eyeball and very rarely penetrate it. They may be pigmented or not. The pigmentation is explained by the fact that the limbus contains pigment, although generally so slight in amount as not to be visible to the naked eye. There is no cachexia, and the liability to metastases is much less than in the case of intraocular growths, but the tendency to recurrences is very great. The disease is rarely met with under forty years of age. On account of the alveolar structure so often present in these tumours, differences of opinion not infrequently arise in the effort to distinguish between sarcoma and epithelioma. The tumour soon becomes surrounded by a localised congestion and, as it grows, it interferes with sight and prevents closure of the lids, but does not cause much pain until the later stages, when ulceration and hæmorrhage are apt to occur.

Epitheliomata are usually non-pigmented and at first may be mistaken for phlyctens—of which, however, the margins are not so steep—or for papillomata (*vide supra*). The surface is wart-like or papillary, or it may be nodular, but the nodules are not so smooth nor so large as in a sarcoma. The cornea becomes infiltrated by the growth and the lymphatic glands may be enlarged.

Sarcomata on the other hand are generally pigmented, the tumour is smooth or nodular, and rarely polypoid, and is not adherent to the cornea, or at least does not involve it except in a very late period.

But conjunctival sarcoma also starts from other parts of the conjunctiva, and in a case at the Royal Victoria Eye and Ear Hospital sarcomatous tumours were four times removed from different parts of the fornix, an interval of some months elapsing between the appearance of each small tumour, and finally enucleation became necessary.

Treatment.—Both epithelioma and sarcoma of the conjunctiva demand prompt operative removal, in order to prevent an extension of the growth to the rest of the eye, as well as to avert metastases to other organs. The knife and actual cautery may save the eye and the patient's life in the early stages. When a recurrence takes place it is safer to remove the eye, more especially if the patient cannot be kept under constant supervision.

CHAPTER VI.

PHLYCTENULAR CONJUNCTIVITIS, AND KERATITIS.[1]

Both from a clinical and nosological point of view it would be incorrect to divide this affection into two, under the heads of Diseases of the Conjunctiva and Diseases of the Cornea; and therefore it is treated of here as one disease, and, being a very important disease, a special chapter is given to it. It is important, because it is excessively common, and because it is capable of causing considerable damage to sight. Moreover, even when it occurs on the cornea, it might, strictly speaking, be regarded as a conjunctival disease, for that corneal layer, which it primarily attacks, is the epithelium, and this—and probably also Bowman's membrane and the anterior layers of the true cornea—as we know from the fœtal development of the membrane, is a continuation of the conjunctiva in a modified form over the cornea.[2]

The disease is characterised by the eruption of phlyctenulæ (*φλύκταινα, a vesicle,* or *pustule*) on the conjunctiva bulbi, on the conjunctival limbus, or on the cornea. It is chiefly a disease of children up to the eighth or tenth year of age, except that it may be said not to occur in the first year of life. It is seen occasionally in adults, and especially in women.

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[1] *κέρας, a horn.*

[2] The posterior epithelium—or, according to some, this along with the membrane of Descemet and the posterior layers of the true cornea —is to be reckoned to the uveal tract; while the true cornea is a modification of the sclerotic.

Notwithstanding the derivation of the word, a phlyctenula, or phlyctene, is originally neither a vesicle nor a pustule. It is a formation *sui generis*, and, when on the conjunctiva, is a solid elevation consisting of a collection of lymph cells, and is of a greyish colour. In a late stage the phlyctenula, especially on the cornea, may become a pustule by infection. On the conjunctiva two types of the disease can be recognised :—

1. **The Solitary,** or **Simple, Phlyctenula.**—Of this there may be one or several, varying in size from 1 mm. to 4 mm. in diameter. The vascular injection is immediately around the phlyctenula, and is not diffused over the conjunctiva, yet it is true that occasionally any form of phlyctenular disease may be associated with simple conjunctivitis, which is to be regarded as secondary to the phlyctenular affection. At first there may be shooting pains and lacrimation, but these soon pass away. If the phlyctenulæ be not seated close to the cornea the affection is not serious ; and the length of time required for its cure depends on the size of the phlyctenulæ, varying from seven to fourteen days, as a rule.

2. **Multiple,** or **Miliary, Phlyctenulæ.**—These are very minute, like grains of fine sand, and are always situated on the limbus of the conjunctiva, which is swelled. The general injection and swelling of the conjunctiva are considerable ; and, occurring as it does almost exclusively in young children, the affection may be called Eczematous Conjunctival Catarrh of Children (Horner). The irritation and so-called photophobia and lacrimation are often considerable, and there is a good deal of conjunctival catarrh. This form is very apt to appear after measles and scarlatina.

Both forms are liable to extend to the cornea, and then only does the disease become serious. This event may come about in the following different ways :—

The Solitary Phlyctenula may be seated partly on the limbus conjunctivæ and partly on the margin of the cornea, and may undergo resolution.

Or it may give rise to a deep ulcer, which either heals, leaving a scar, or perforates, causing prolapse of the iris, etc

Or it may form the starting-point of a fascicular keratitis, the pustule becoming an ulcer, at the margin of which the corneal epithelium is raised and infiltrated in crescentic shape. This now steadily advances for many weeks towards the centre of the cornea, followed by a leash of vessels which has its termination in the concavity of the crescent. The process is accompanied by much irritation of the terminal branches of the fifth nerve in the cornea, and the consequent reflex blepharospasm. A permanent mark indicates the track of the ulcer.

The Multiple Miliary Phlyctenulæ on the limbus conjunctivæ may cause some slight superficial infiltration and vascularisation of the cornea in their immediate neighbourhood, which pass off when the phlyctenulæ disappear.

Or they may be accompanied by deeper marginal infiltrations of the cornea, which become confluent and result in an ulcer that extends along the margin of the cornea for some distance, and is termed a Ring Ulcer. It is a serious form of ulcer; for if it extend far round it may destroy the cornea in a few days by cutting off its nutrition.

Primary Phlyctenular Keratitis occurs principally in three different forms:—(1) Very small grey sub-epithelial infiltrations, which are apt to result in small ulcers, and then heal, leaving a slight opacity. This opacity may ultimately quite disappear, especially in the case of children, and when situated peripherally. (2) Somewhat larger and deeper infiltrations, resulting in ulcers of corresponding size, which heal by aid of vascularisation from the margin of the cornea. The opacity left after these ulcers is rather intense, and clears up but little, especially if the situation be central. (3) Large and deep-seated pustules, due to secondary infection, often at the centre of the cornea, giving rise to large and deep ulcers, which may be accompanied by hypopyon and even by iritis, and which frequently go on to perforation.

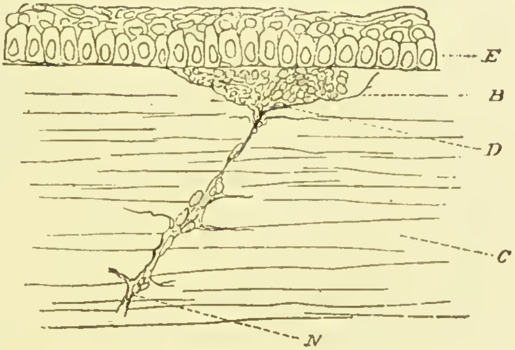


FIG. 107.—*E*, Epithelium; *B*, Ant. elastic Lamina; *C*, True Cornea *N*, Nerve Filament, with Lymph Cells on its course; *D*, Phlyctenula.

Photophobia is usually a prominent symptom in phlyctenular keratitis. The term photophobia, however, is not altogether correct, for it is the fifth nerve (from the cornea) which is mainly the afferent nerve here rather than the optic nerve. This is evident from the fact that in the dark the patient does not get complete relief. The explanation of this reflex blepharospasm has been given by Iwanoff, who showed that the round cells, in making their way from the margin of the cornea to their position under the epithelium, follow the course of the nerve filaments, which they irritate in their progress. The accompanying Figs. 107 and 108 are from his original paper.

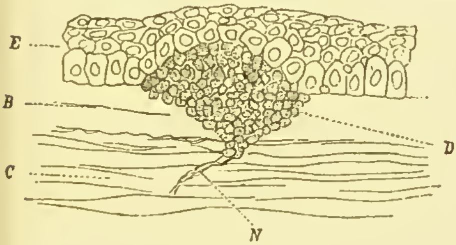


FIG. 108.

Enlarged cervical glands, eczema of the eyelids, face, and external ear, and catarrh of the Schneiderian mucous membrane, frequently accompany phlyctenular conjunctivitis and keratitis.

In these cases, in children of three or four years of age, temporary amaurosis has sometimes been observed after a severe and long-continued blepharospasm has passed away. The patient is found to be unable to see even large objects, or to find his way, although the pupil-reflex is active, and a strong light may still be distressing. There are no ophthalmoscopic appearances. This blindness passes away completely, usually in from two to four weeks, although the interval before recovery of sight may be several months. A certain mental dulness, which also ultimately disappears, is noticed in some cases. This temporary loss of sight has been regarded as a reflex phenomenon, and again it has been held to be due to disturbance of the intraocular circulation from pressure of the eyelids on the eyeball. But the view (Leber, Uhthoff) which represents it as having a cerebral origin of a functional nature is probably the correct one. It is likely at this tender age, when the psycho-physical processes are not as yet firmly established, that the desire not to see, and the active withdrawal from the act of vision, leads in a short time to a functional paralysis of the visual centres in the brain, and that these take some time to recover, or to re-learn, their functions, when the ground for the suspension of the latter has ceased.

As a result of frequent relapses of phlyctenular keratitis, a superficial pannus-like vascularisation may form in the cornea, in those regions of it which have been chiefly attacked.

Cause.—As already stated, this is a disease of childhood, although it is extremely rare in the first year of life. In adults it is uncommon.

The strumous constitution—as indicated by the swollen nose and upper lip, and sometimes by the enlarged lymphatics in the neck, and by the eczema—allied to tuberculosis, is that most liable to this affection. Often, however, it will be found in strong children with apparently perfect general health; but even in them there is probably some irregularity of nutrition, of which the great tendency to recurrence of the eye affection is evidence.

Colonies of straw-coloured micrococci may be found in the contents of the phlyctenulæ; but what, if any, etiological relationship they have to the production of the latter is unknown.

Treatment.—The solitary phlyctenula of the conjunctiva is best treated with a 2 per. cent. yellow oxide of mercury ointment, of which the size of a hemp-seed should be put into the eye with a small glass rod, once a day. To obtain the best result with this ointment, its base should consist of 10 parts of pure white vaseline, and one part each of anhydrous lanoline and water. The yellow oxide is to be freshly precipitated and in very fine powder, and when it has been well rubbed up with the water, the anhydrous lanoline and vaseline are added. This ointment contains no fatty substance, and consequently mixes with the tears and comes thoroughly in contact with the surface of the eye. Ordinary lanoline contains olive oil. The ointment should not be unnecessarily exposed to light or air. Or, a small quantity of pure calomel dusted into the eye once a day will also cure; but this remedy should not be employed if iodide of potassium is being taken internally, for then iodide of mercury is liable to be formed in the conjunctiva.

The miliary phlyctenular conjunctivitis may be treated at first with cold or iced applications. Freshly prepared chlorine water (1 part Liq. Chlori., 9 parts water), to be dropped into the eye once a day, is recommended by some, and later on Liq. plumbi dil. or Sol. argent. nitr. (gr. v ad ℥j, and neutralised) applied to the everted conjunctiva; or, if the phlyctenular appearance predominate over the catarrhal, the yellow oxide of mercury ointment or insufflations of calomel may be preferred. Indeed, practically, the two latter remedies are applicable in all these cases.

When the cornea is slightly affected near the margin in cases of miliary phlyctenulæ, calomel, or the yellow oxide of mercury ointment, and warm fomentations, should be used.

Where a large pustule on the margin of the cornea has resulted in a deep ulcer, with tendency to perforate, and accompanied by much pain, paracentesis of the anterior chamber through the floor of the ulcer, the pupil having first been brought well under the influence of eserine to prevent prolapse of the iris, cannot be too strongly advocated. The good effect of this will be very soon apparent: the pain disappears, the patient sleeps, the ulcer becomes vascularised, and healing sets in. Cauterisation of the ulcer in an early stage with the galvano-cautery is also good practice; but in these cases paracentesis is preferable. Many surgeons trust too much to eserine, warm fomentations, and a pressure bandage.

For the fascicular keratitis the yellow oxide of mercury ointment is again in its place. When the crescentic infiltration is very intense it is well to touch it with the galvano-cautery.

For the ring ulcer a pressure bandage, under which an antiseptic dressing (boric or salicylic acid, or perchloride of mercury) has been placed, is, perhaps, the best method of treatment. Warm fomentations promote vascular reaction, and may be used with benefit at each change of bandage.

For primary phlyctenulæ of the cornea, in the form of the minute grey superficial infiltration or ulcer, nothing beyond atropine, with warm fomentations, and a protective bandage to keep the eyelids quiet, should be used. When reparation of the ulcer has commenced, calomel or weak yellow oxide of mercury ointment may be employed.

For the large infected phlyctenula, resulting in a large and deep ulcer, often situated at the centre of the cornea, with hypopyon and iritis, warm fomentations (camomile, or poppy-head, at 90° Fahr., for twenty minutes three times a day), atropine, boric acid as ointment or powder, and a protection bandage form the treatment in the early stages. Here, also, the ulcer may be punctured with the very best results in respect of hastening the cure, or the galvano-cautery may be used with advantage. In the stage of reparation the yellow oxide of mercury ointment or insufflations of calomel are very useful.

In nearly all cases of phylctenular keratitis dionine (5 per cent. solution) aids the cure.

In all forms of phlyctenular ophthalmia those favourite remedies, blisters, setons, and leeching, should be avoided. The first two worry the patient, give rise to eczema of the skin, and are not to be compared in their power of cure with the measures above recommended; while leeching gives, at best, but temporary relief, and deprives the patient of blood which he much requires.

For relief of the blepharospasm, in addition to the use of atropine, plunging the child's face into a basin of cold water is a most efficacious means. The face is kept under the water until the child struggles for breath, and this immersion is repeated two or three times in rapid succession, and used every day if necessary. It should always be used where the blepharospasm is severe, as the latter is not only distressing to the patient, but also an obstacle to the cure.

The general treatment, notwithstanding the so-called photophobia, should consist in open-air exercise before everything else, unless, indeed, there be an ulcer which threatens to perforate. It is not well to keep the eyes (unless there be a corneal ulcer) or patient's face covered with bandages and shades, nor to confine him to a dark room. A pair of dark-blue glasses are the best protection from strong glare of light; and shady places can be selected when the patient is out of doors. Cold or sea baths, followed by brisk dry rubbing. Easily assimilated food at regular meal hours, but no feeding between meals. Regulation of the bowels.

Internally: cod-liver oil, maltine, iron, arsenic, syrup of the phosphate of lime, and such-like remedies are indicated.

The great tendency to recurrence is one of the most troublesome peculiarities of all kinds of phlyctenular ophthalmia; and in order to prevent this, so far as possible, it is important, not only to improve the general health, but also to continue local treatment until the eye is perfectly white on the child's awaking in the morning, and even for fourteen days longer. This prolongation of the treatment will also assist in clearing up opacities, as best they may be. For this after-course of treatment calomel insufflations should be used.

Nothing can be done for the opaque scars left on the cornea by ulcers when all inflammatory symptoms have subsided. If the ulcer have been very superficial the resulting scar in young children may disappear in the course of time. Deep ulcers cause more opaque and permanent scars, and ulcers which have perforated produce the greatest opacity. Some of the very disfiguring scars may be tattooed (see chap. vii.).

The degree of the defect of vision to which an opacity of the cornea may give rise depends, in the first instance, on the position of the opacity. If it be peripheral, the vision may be perfect; but if it be in the centre of the cornea, sight may be seriously damaged. Even a slight nebula, barely visible to the observer, will cause serious disturbance of vision if situated in the centre of the cornea; while in the same situation the very opaque scar of a deep ulcer will produce a proportionately greater defect. If a central, but not deep, ulcer should not become completely filled up in healing, and a facet remain, vision will also suffer much in consequence of irregular refraction, although there may be but little opacity.

CHAPTER VII.

DISEASES OF THE CORNEA.

THE importance of a knowledge of the diseases and injuries of the cornea depends on their great frequency, coupled with the fact that nearly every one of them is liable to leave behind it some opacity, with resulting defect of sight and disfigurement of the eye; while several of them are very apt to lead to complete loss of sight.

CLINICAL METHODS OF EXAMINING THE CORNEA.

1. By Diffuse Daylight. The patient having been placed with his face towards the window, the cornea is carefully inspected. The patient is required to keep both eyes open, while his upper lid is gently raised with the surgeon's thumb, and to direct them upwards, downwards, to the right, and to the left, so that every part of the affected cornea may be seen under the most favourable and varied incidence of the light. Should there be much reflex blepharospasm, the instillation of cocaine, by producing anæsthesia of the cornea, assists the examination. With small children it is often necessary to adopt the plan illustrated by Fig. 91.

2. By Focal, or Oblique, Illumination. In the dark room the light of the ophthalmoscope lamp is focussed with a + 14·0 lens on the cornea, which is thus seen brilliantly lighted up. The lamp must be placed in front of and slightly to the left-hand side of the patient, and about two feet from his eye. The lens is placed between the lamp

and the eye, so that the light may be concentrated by it on the cornea.

3. By the Combined Focal Method, that is focal illumination as above, combined with the use as a magnifying-glass of a second +14·0 lens. The second lens is held between the finger and thumb of the left hand some inches from the patient's eye, while the surgeon places his eye at the focus of the glass, the cornea being at the same time illuminated by the light focussed on it with the other lens held between the finger and thumb of the right hand. Changes in the cornea are then seen magnified, and at the same time highly illuminated.

4. By the Ophthalmoscope with a +18·0 or +20·0 lens behind the sight-hole of the mirror. The surgeon proceeds as though he were about to examine the fundus in the erect image. The cornea is illuminated from the mirror, and changes in it are magnified by the + lens through which it is inspected.

5. By Fluorescine. In cases of ulcer, or any abrasion of the corneal epithelium, when it is desired to ascertain accurately the whole extent of the loss of substance, or if there be some hesitation as to the presence of such a lesion, an instillation of a drop of fluorescine solution (Fluorcsein. gr. ij, Sodii Carb. gr. j, Aq. destill. ʒ ij) is used. About half a minute after the instillation, the whole region which is denuded of epithelium will be seen stained of a greenish yellow colour. In some instances where there is no true loss of substance, staining takes place if the epithelium be not sound. An ulcer, which in the process of healing has become covered with sound epithelium, will not stain, although there may still remain some loss of substance to be filled up. Fluorescine does not harm the cornea, nor interfere with healing of any diseased process in it, and the staining passes away after a short time.

The foregoing methods are in everyday use.

6. By the Corneal Microscope. This is an elaborate optical instrument, which forms the outfit of a well-equipped ophthalmic hospital, for the minute study of diseased states of the cornea and iris. It is not needed for ordinary clinical work, and therefore a description of it will not be given here.

INFLAMMATIONS OF THE CORNEA.

From a clinical standpoint these inflammations will be most conveniently considered under the headings—(*a*) Ulcerative Inflammations, and (*b*) Non-ulcerative Inflammations.

(*a*) ULCERATIVE INFLAMMATIONS OF THE CORNEA.—Before an ulcer can form in the cornea there must be a cellular infiltration of its tissue near its anterior surface; and this cellular infiltration is brought about, in most instances, if not in all, by the entrance into the cornea of certain micro-organisms, pneumococci, diplobacilli of Morax, staphylococci, streptococci, bacillus subtilis, etc. One recognises the existence of an infiltration by seeing an opaque spot in the cornea, with a dulness of the layers over it, and often of the corresponding part of the epithelium. Before long the epithelium covering the infiltration undergoes necrosis and comes away, and soon the intervening layers of the true cornea also break down, and in this way an ulcer becomes established.

But although all ulcers of the cornea originate in an infiltration, yet, once established, they assume great varieties of type, in consequence, probably, of a variety in the nature of the originating micro-organisms. Some ulcers are purulent, others non-purulent; some tend to spread over the surface of the cornea, others tend to go deep into it; the progress of some is very rapid, and of others exceedingly chronic; some attack by preference the central region of the cornea, while others are confined to its margin; some readily give way to treatment, and others are very obstinate or almost incurable.

Again, some ulcerative corneal processes are attended by much irritation: that is to say, circum-corneal injection, severe pain in and about the eye, great reflex blepharospasm, and lacrimation; whilst others, which may really be more severe processes in so far as the integrity of the eye is concerned, can run their course with hardly any injection of the eyeball, and with little or no distress to the patient.

Etiologically, corneal ulcers are primary or secondary. The primary ulcers are those in which the diseased process originates in the cornea, most commonly as the result of traumata, but also in phlyctenular keratitis, or as the result of corneal abscess, or where the nutrition of the cornea is interfered with, etc. Secondary ulcers are those which are the result of disease elsewhere, usually in the conjunctiva, as in acute blennorrhœa and in conjunctival diphtheritis.

Corneal ulcers are more common in advanced than in early life. Indeed, in early life, unless in cases of infantile ulceration with conjunctival xerosis, of blennorrhœa neonatorum, and of phlyctenular disease, corneal ulcers are almost unknown. The greater liability to these affections in advanced life is due, it may be assumed, to a less active nutrition at that period in this already lowly organised part. Hence slight traumata, or the presence of a slight conjunctival catarrh, which would have no ill effect in a young person, may form the starting-point of a corneal ulcer in an old person, or even in one of middle age. For the same reasons, corneal ulcers are much more common in the poorer classes than amongst the well-to-do; for their general nutrition is often defective, while they are more exposed to traumata than are the better classes.

The Diagnosis of the presence of a large corneal ulcer is simple. Inspection of the cornea in ordinary daylight at once reveals the loss of substance, more or less extensive, deep, or infiltrated. If the ulcer be very small and shallow the difficulty is greater, especially if there be much blepharospasm. An instillation of cocaine may be necessary to facilitate the examination.

It is obviously important to decide at the outset, for the purposes of prognosis and of treatment, whether a grey spot in the cornea be an infiltration (a collection of cells which may shortly break down and become an ulcer), an ulcer, or a scar (the result of an ulcer, or other loss of substance). The surface covering an infiltration, although flush with the general surface of the cornea, has usually a steamy appearance, due to disorganisation of the corneal epithelium, and has no lustre. With an ulcer the appearances already described will be found. The surface of a scar is usually, although not always, flush with the general surface of the cornea, and it has a bright surface—*i.e.*, covered with normal epithelium, not rough, irregular, nor even steamy. In cases of corneal infiltration, or ulceration, there will be usually more or less pericorneal injection, pain, and photophobia, while with a mere corneal scar there will be no irritation of the eye. Fluorescin stains an ulcer, and sometimes an infiltration if it be near the surface, but not a cicatrix.

The presence of *Hypopyon* (*ὑπό, under ; πῦον, pus*) is the rule with several types of corneal ulcer, notably the deep ulcer, and the serpiginous ulcer. The term 'hypopyon ulcer,' which is so much used, should certainly be discarded, as hypopyon is not the characteristic of one type of ulcer. Hypopyon is a deposit of pus in the anterior chamber, and as the patient sits or stands it lies in the lowest part of the chamber, to which place it has gravitated. If the patient lie in bed, say on the side of the affected eye, the hypopyon will of course change its position, and gravitate towards the temporal side of the chamber. Sometimes the hypopyon is so small as to be detected with difficulty ; and again it may fill the whole anterior chamber, completely obscuring the iris and rendering a diagnosis of the condition of the cornea difficult. It will be asked, From whence does the pus come which forms hypopyon in cases of corneal ulcers? It might be supposed that it is derived directly from the purulent floor of the ulcer, by passage of the pus-cells through the posterior layers of the cornea. But this is not so. No pus-cells do, or indeed can, pass through the membrane of Descemet. Moreover, copious hypopyon is often present, when the corneal ulcer is quite small and non-purulent. The pus-cells, which form hypopyon in cases of corneal ulcer, come from the iris, in compliance with the law which causes leucocytes to wander out of blood-vessels in the neighbourhood of an inflammatory focus, and to make their way towards that focus. When these leucocytes from the iris reach the anterior chamber they can go no farther, owing to the barrier imposed to their progress by the membrane of Descemet. The pus forming a hypopyon is sterile.

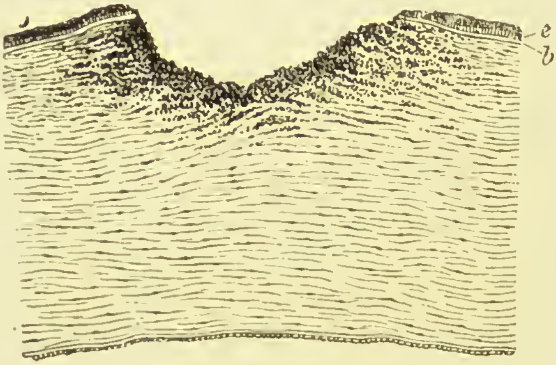


FIG. 109 (*Fuchs*).

The Dangers attendant upon Corneal Ulcers are, first of all, the opacities, the scars, which even the slightest of them are apt to leave behind.

Fig. 109 represents a section made through a deep ulcer in its progressive stage. At the margin of the ulcer the epithelium (*e*) and Bowman's membrane (*b*) cease. The floor of the ulcer is seen covered with pus, which also infiltrates the corneal tissue beneath the floor and around the margin.

As soon as cure commences the floor of the ulcer begins to clear, *i.e.*, it becomes gradually less covered with pus, until it is finally quite free from it, and *pari passu* the surrounding infiltration of the cornea is absorbed. Then the epithelium, growing in from the margin (*m m*, Fig. 110) all around, gradually carpets over the floor of the ulcer, and underneath this newly formed epithelium the new tissue, which is to close in the loss of substance, is laid down. This new tissue, however, is not normal corneal tissue, but is ordinary connective tissue, and is therefore opaque. Hence the

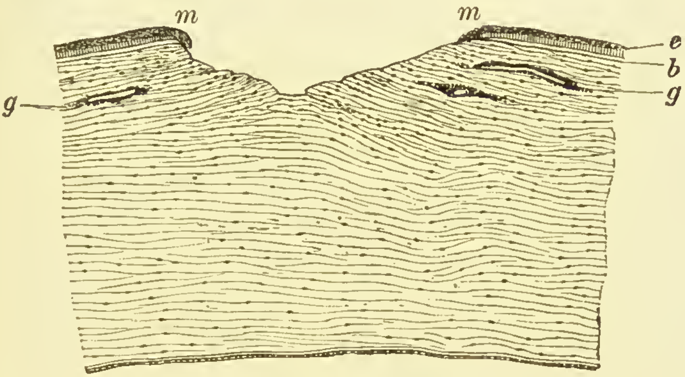


FIG. 110 (*Fuchs*).

leeper the ulcer, the more intense will be the resulting pacity. Bowman's membrane never becomes restored over he cicatrix.

The ulcers which are situated at the centre of the cornea, n the pupillary area, are more serious for sight than those ituated peripherally, as can be readily understood. The pacity left by a very superficial ulcer is slight, and is alled a nebula; a somewhat more intense opacity is alled a macula; and a very marked white scar is called a eucoma.

But a more serious danger connected with ulcers of the ornea than the opacities they leave behind is that of perforation of the cornea, to which some ulcers are very prone. The consequences of perforation are prolapse of iris, resulting in anterior synechiæ, adherent leucoma, or staphyloma of the cornea (see pp. 150, 151, 217, 253), and fistula of the cornea (p. 223).

Treatment.—In the treatment of primary corneal ulcers the student will soon observe that a bandage, atropine, and warm fomentations play prominent parts; and these routine measures alone are sufficient to produce cure in the less severe cases.

The bandage should be put on with firm pressure,—but should not be made uncomfortably tight,—the eye having been proviously padded out, especially at the inner canthus, so that equal pressure may be exercised on the globe all over. The support thus given to the cornea and front of the eye promotes the healing process, and the bandage is also useful by preventing the eyolids from rubbing over the ulcer, and by protecting it from foreign bodies. In those secondary ulcers, which are due to conjunctival processes, such as catarrhal conjunctivitis or blennorrhœa, a bandage is contraindicated, because it retains the secretion, and would therefore do harm rather than good.

Atropine in sufficient quantities to keep the pupil dilated should be employed. Iritis very often attends severe corneal ulcers, and here the indication for atropine is obvious. But rest of the affected part is, we know, an important element in preventing or in curing any inflammation; and in the affections we are now treating of, even if there be no iritis, atropine acts by procuring rest of the iris and of the ciliary muscle, the constant motion of which would otherwise tend to augment the inflammatory process in the cornea.

Myotics are preferred by some to mydriatics in the treatment of corneal ulcers, on the ground that the action of myotics in reducing the intraocular tension promotes healing, and that the more extended surface of iris—more extended absorbing surface—facilitates absorption of hypopyon. It is not certain that myotics do reduce the normal tension, and in these cases they undoubtedly increase the tendency to iritis. As to absorption of the hypopion it will come about in due course when the cornea begins to recover. Yet a clear indication for myotics is given by the presence of an ulcer near the corneal margin, which has a tendency to perforate, for here the myosis would assist in preventing prolapse of the iris, should perforation take place.

Dionine is useful in the treatment of many cases of primary corneal ulceration and other primary corneal diseases. Its physiological action is to cause dilatation of the lymphatic vessels of the conjunctiva with great chemosis, although it does not act equally in every eye, and its therapeutic effect is held to depend on this lymphatic flooding of the front of the eye. It is used in a 5 per cent. solution dropped into the eye once or twice a day. If employed frequently it ceases to produce any reaction, and for this reason it may be desirable in some cases to use it once only on alternate days. It causes slight anæthesia of the cornea.

Warm fomentations promote the healing process by stimulating tissue-changes in the cornea. One usually orders them to be made with poppy-head water or camomile tea, although no doubt warm water would be equally efficacious. Hot solutions of 4 per cent. boric acid, or 1 in 5000 corrosive sublimate, may be used with advantage. The bandage having been removed, a compress of cotton wool which has been dipped in the stupe at about 120° Fahr. is laid upon the eye, and frequently replaced by fresh compresses out of the stupe, so that the compress on the eye may always be hot. This is continued for half an hour at a time, and repeated every two or three hours. Or, the Japanese muff-warmer may be applied.

In an ulcer of a purulent or sloughing nature, the insufflation on its floor of very finely divided xeroform powder is useful.

When more active measures than the foregoing are called for, the actual cautery, curetting, paracentesis, and subconjunctival injections have to be resorted to.

The actual cautery is much in use in the treatment of serpiginous and other infected corneal ulcers. It acts by destroying the micro-organisms, which keep the process going. Either a thermo-cautère, in the form of a very fine point, or the galvano-cautery (Fig. 11), the platinum wire being at a red-heat, may be employed. The eye having been cocainised, the red-hot point is brought into contact with the whole surface of the ulcer, so as to thoroughly destroy its superficial layer, and special attention is given to any part of the margin of the ulcer where there is a tendency to spread to as yet healthy tissue. Fluorescine may be used to show the exact extent of the ulcerated surface. The cauterisation can be repeated as often as the state of the ulcer may make it desirable. It is sometimes well to perforate the cornea with the cautery, and to evacuate the aqueous humour and hypopyon; or this may be done with an ordinary paracentesis needle, after the cauterisation is completed. The cautery gives a good percentage of cures with the least amount of opacity.

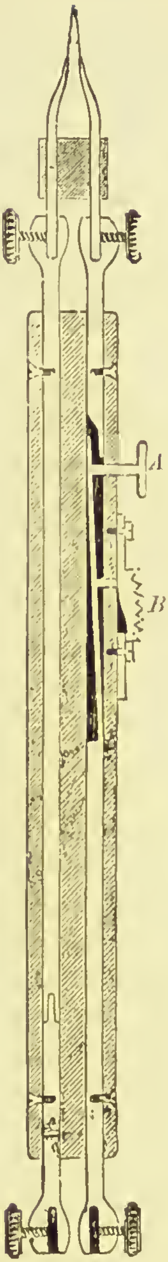


FIG. 111.

FIG. 111.—The bolt *B* being pushed forwards, the circuit is completed. By pressure on the button *A* the current can be momentarily intercepted during use of the instrument.

Thorough curetting of the floor of the ulcer with a small sharp spoon is a valuable method, either alone or prior to cauterisation.

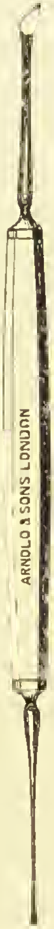


FIG. 112.

Paracentesis of the anterior chamber through the floor of the ulcer is another most valuable therapeutic measure for some corneal ulcers, and deserves a more routine application in these cases than is accorded to it; the more so as the little operation is simple and dangerless. But there are two imperative indications for its use, namely:—(1) If there be great pain. Soon after the operation, which for a short time increases the neuralgia, the patient experiences the greatest relief, and passes the first good night after many wakeful ones. (2) If perforation seem to be imminent. This may often be recognised by a bulging forwards of the thin floor of the ulcer; but sometimes it is not easily foreseen, and if there be any doubt on the point, paracentesis should be performed. It is important to forestall spontaneous perforation of the ulcer by this proceeding, because the opening that is made being linear heals easily, and leaves but a slight scar without anterior synechiæ; while the natural opening would be a complete loss of substance, and would, therefore, the more readily involve adhesion of the ris in the resulting, and comparatively extensive, icatrix. Other indications for the operation are ncreased tension, and the presence of a large ypopyon.

Paracentesis of the anterior chamber is best performed y means of a paracentesis needle (Fig. 112), which is a mall somewhat shovel-shaped blade. If this be not at and, a small keratome, or a broad needle, or a Græfe's ataract knife will answer the purpose. The eye having een cocainised, a spring lid-speculum is inserted, the eye ixed with a fixation forceps, and the point of the paracentesis needle applied to the floor of the ulcer, in such a way that the plane of the little blade may be at an angle of about 45° with that of the floor of the ulcer. The point is pushed gently through the floor, and the plane of the blade is then immediately changed, so that, as the instrument is being advanced up to the hilt, it may be almost in contact with the posterior surface of the cornea. The instrument should be withdrawn very slowly, in order that the aqueous humour may flow off gradually, and not with a rush. If these precautions be taken, there need be no danger of injury to the crystalline lens, or of prolapse of the iris into the incision. Should prolapse occur, it can usually be reposed with the spatula. It may happen that when the needle has been withdrawn a considerable portion of the aqueous humour may remain in the anterior chamber, unable to escape owing to the valve-like closure of the wound. It should be evacuated by making the wound gape by gentle pressure with a spatula on its posterior lip. If it be desirable to tap the anterior chamber on the next day, this can be done by simply opening up the wound with a spatula, or with the probe-like instrument at the other end of the handle (Fig. 112), without the aid of any cutting instrument.

Subconjunctival injections of solution of oxycyanate of mercury (1 in 5000) or of solution of chloride of sodium (4 per cent.) enter largely into the therapeutics of corneal disease, and of disease in the uveal tract. It is not necessary that the injections should be made under the capsule of Tenon as was at first supposed. The mode of action of these injections is not clearly understood. It is not due to the entrance of the preparations into the tissue of the cornea or interior of the eye, for only minimal quantities of even mercurial salts have been found in the vitreous humour. It was at first believed that they acted as lymphagogues, but their curative power is now held to depend on the vascular reaction to which they give rise. Of the oxycyanate of mercury solution 5 to 10 minims according as it can be borne, and of the saline solution 10 to 20 minims are injected under the bulbar conjunctiva in the direction away from the cornea. Other solutions (sublimate, hetol, cyanate of mercury, iodipin, iodide of potash, etc.) have been employed, but these two are as efficacious as any. From 2 to 5 minims of a 1 per cent. solution of acoine may be taken up in the syringe with the main solution, just before the injection is made, in order to diminish the severe pain and irritation which comes on afterwards and lasts often for several hours. This pain may be much relieved by hot fomentations, but if it be very intense a hypodermic injection of morphia may be necessary. Considerable vascular injection and chemosis may be present next day, and the eyelids may be swollen and œdematous. The injection should not be repeated until the redness and œdema have almost subsided. Few eyes require, or can tolerate, more than two injections in the week. (See also chap. xi.).

If the case do not come under the care of the surgeon until perforation of the ulcer with prolapse of the iris has taken place, the important question as to the best method of dealing with the condition is presented. If the loss of substance should occupy one third or more of the cornea with correspondingly large prolapse of iris, the development of a staphyloma is almost inevitable. Eserine is to be used to reduce the intra-ocular pressure, and a firm bandage is to be kept applied to the eye. And here transplantation of conjunctiva over the ulcer and prolapsed iris to strengthen the cicatrix (*vide infra*) is indicated. But if the ulcer and prolapse be small, an attempt may be made to free the iris, so that no anterior synechia may form, and in order that the cicatrix may be flat, and not raised over the surface of the cornea, and, consequently, exposed to injury. The importance of such an attempt lies in the fact that a corneal cicatrix with iris entangled in it—not merely adherent to its posterior surface—affords a constant source of danger, especially if situated near the margin of the cornea; for in such eyes, it may be years later, sudden and uncontrollable purulent inflammation of the iris and chorioid may come on from septic infection after an apparently slight trauma of the cicatrix, and rapidly end in total destruction of the eye. The surgeon's attention should therefore be directed to obtain at least as flat a cicatrix as possible, or, still better, a non-adherent cicatrix. The practice which is commonly followed, is to draw the freshly prolapsed portion of iris slightly forwards with a forceps, and to snip it off level with the surface of the cornea; and then with a spatula to endeavour to free the iris from any adhesions it may have formed with the margin of the ulcer. Atropine or eserine, according to the position of the ulcer, is then instilled, and a bandage carefully applied. This proceeding is only of use when a fresh prolapse can be dealt with, before cicatrisation sets in; and the result is often satisfactory in so far as the securing of a flat cicatrix is concerned, but an anterior synechia can rarely be avoided.

* Da Gama Pinto's method for obtaining a non-adherent cicatrix is sometimes useful :—Having abscised the prolapsed portion of iris as above, and freed all adhesions to the margin of the ulcer with a spatula, he covers the opening in the cornea with a flap cut from the bulbar conjunctiva, —and this flap should be twice as large as the opening, in order to admit of its shrinkage,—and then pushes the flap into the opening with a blunt probe. A firm binocular bandage is applied—but no iodoform. The eye is not dressed until the third day, when the anterior chamber is often found restored, the iris all in its proper plane, and the conjunctival flap healed into the ulcer. Ultimately all trace of the flap disappears, and an ordinary non-adherent corneal scar is presented.

* Kuhnt's method, too, for strengthening the cicatrix, where

an extensive ulceration with prolapse is present, by means of a conjunctival flap, with single or double pedicle, which is drawn over the ulcer, is a valuable one. If the ulcer and prolapse be at *a* (fig. 113), an incision *b c* is made through the conjunctiva along the margin of the cornea, and an incision *d e* more peripherally. The flap so outlined is dissected up, drawn over the cornea, ulcer, and prolapse of iris, and then secured to its new position by means of a suture (Fig. 114). In a few days the flap becomes adherent to the ulcer and prolapse, and its upper and lower positions can thus be released with the scissors. By this means a stronger covering for the ulcer and prolapse is provided, and the dangers of late nfection and of staphyloma are minimised.

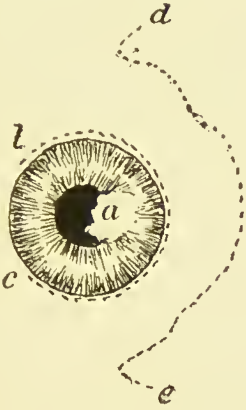


FIG. 113.

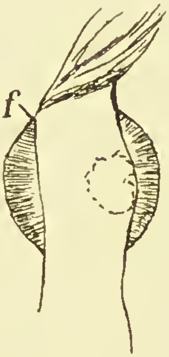


FIG. 114.

Different types of corneal ulcers are recognised and escribed. Of these the following are the chief :—

Simple Ulcer.—This may result from a slight trauma, it may originate in a phlyctenula. It presents the ppearance of a minute and shallow depression with a grey oor on the surface of the cornea. There is circumcorneal scularity, especially at that part of the corneal margin earest to which the ulcer is situated ; the pupil is apt to be contracted, although iritis is not present, and there is often a good deal of pain, lacrimation, and photophobia.

Treatment and Prognosis.—The eye is to be bandaged, warm fomentations applied several times a day, and a drop of solution of atropine instilled night and morning. When of phlyctenular origin, stimulation with the yellow oxide ointment is indicated. Dionine may be used. Cure, with slight opacity remaining, comes about in a week or ten days. But, if it become infected, this form of ulcer may pass over to the deep ulcer.

Deep Ulcer.—This is a septic or infected ulcer, and commences in a septic infiltration of the cornea. It forms a tolerably deep pit in the cornea towards its centre, the floor of the ulcer being covered with purulent deposit and detritus, and the corneal tissue immediately surrounding it being somewhat infiltrated with pus. The ulcer is generally round, but it may assume any shape. Hypopyon is often present, and a marked tendency to iritis exists. The pain is usually very severe, violent frontal neuralgia being a common symptom.

This ulcer has no great tendency to spread over the surface of the cornea, but has a very decided tendency to perforate through it. As it does not generally attain wide dimensions, the perforation it may produce is small, and gives rise to a small adherent leucoma rather than to a staphyloma. It seldom causes complete loss of the eye.

Causes.—This form of ulcer is a frequent one in gonorrhæal ophthalmia and in blennorrhœa neonatorum; and it may be caused by the lodgment of foreign bodies, and other injuries of the cornea.

Treatment.—If the ulcer be due to a conjunctival process, the latter should be actively treated, and the only attention needed for the ulcer is to anticipate with paracentesis a spontaneous perforation.

If the cause be other than conjunctival, a pressure bandage to give support to the ulcer is important, and periodical warm fomentations are most beneficial; but where the cause is conjunctival (purulent conjunctivitis), neither a bandage nor warm fomentations can be used. Atropine should be instilled in all cases several times daily, and antiseptic applications, especially xeroform, are useful.

Paracentesis of the anterior chamber through the floor of the ulcer is a proceeding always followed by improvement in the condition of the eye, and is very important as a preventive of natural perforation. The actual cautery, too, is in its place here, except when the ulcer is due to purulent conjunctivitis.

* *Fistula of the Cornea.*—The deep ulcer when it perforates is the most common cause of fistula of the cornea. A fistula is liable to form when the perforating ulcer is in the pupillary area of the cornea, so that it cannot be closed by the prolapse of iris into it. The opening closes then by the slow growth of connective tissue from its margins, and sometimes this process does not go on to completion, and then a small central fistula is left. Or, the perforation takes place so that just a small tag of the pupillary margin of the iris is incarcerated in the cicatrix, and the pulling of the iris on this as the pupil dilates prevents complete closure of the orifice. Or, if the perforation be of wide area, with extensive iris-prolapse, the pressure of aqueous humour may cause a small rupture in the prolapse which may not heal again. Through the fistula aqueous humour constantly trickles away, the anterior chamber remains very shallow or quite empty, the globe is soft, and gradually becomes softer; or, the fistula closes for a time, the eye then becoming of glaucomatous hardness, and the high tension ruptures the cicatrix, which again closes, and is again ruptured by high tension. Finally, sight is lost through detachment of the retina, or through severe uveitis or hæmorrhage.

Fistula of the cornea is very difficult of cure. The treatment consists in the use of a myotic to keep the intraocular tension low. With the same object an iridectomy is indicated, but is difficult of performance owing to the shallow anterior chamber. The margins of the fistula may be curetted, or cut away, or cauterised, but the close proximity of the lens must be borne in mind, lest its capsule be injured by these proceedings. The anterior surface of the opening may be curetted, and a conjunctival flap with pedicle transplanted over the opening (p. 221); the flap healing to the curetted margin aids in the closure of the fistula. Or, into the opening, the margins of which have been previously curetted, a small flap of conjunctiva without pedicle may be pushed, which, healing with it, closes the opening.

Serpiginous Ulcer (Ulcus Serpens, Sæmisch's Ulcer). This, also, is a purulent ulcer, a characteristic of which is its tendency to creep over the surface of the cornea, especially in some one direction, rather than to strike deep into its tissue. Its position is chiefly central, and it presents a greyish floor, which is more intensely opaque at some places. One part of the margin takes the form of a curve, or of several closely placed curves, and at this place the margin becomes yellowish-white in colour and somewhat raised, and the floor of the ulcer seems deeper in its neighbourhood. Immediately around the ulcer the cornea is slightly opaque, but farther out it is normal.

The degree of pain and irritation varies much, being almost absent in some cases, while in others it is intense. Iritis is apt to come on at an early period, and may pass into irido-cyclitis. Hypopyon is almost always present, and on the posterior surface of the cornea, from the region corresponding to the ulcer on the anterior surface, a line of pus is sometimes seen extending down to the hypopyon, and this was formerly taken as a proof that the hypopyon was formed by direct transmission of the pus corpuscles through the cornea from the ulcer. The ulcer creeps over the surface of the cornea in the direction of the curved and intensely infiltrated margin. At a still later stage the whole cornea is apt to become infiltrated, and the entire margin of the ulcer to extend, and the anterior chamber becomes quite full of pus. Perforation now takes place, or may do so somewhat earlier. If the perforation be small, an adherent leucoma results; but if large, a staphyloma gradually develops, or panophthalmitis may immediately follow on the perforation.

Causes.—Ulcus Serpens always has its origin in a trauma, which has produced, it may be, only a slight abrasion of the epithelium. In perhaps 50 per cent. of the cases chronic dacryocystitis is present, and in about 25 per cent. more there is ozœna, and a considerable proportion of them occur in the warm summer months.

In most instances the pneumococcus—the usual micro-organism of chronic dacryocystitis—is the excitant of the typical ulcus serpens, but occasionally cases have been observed in which the pneumococcus was not present, and the diplobacillus liquefaciens, the streptococcus, the bacillus subtilis, or some rarer form of micro-organism, was held to be the excitant.

Prognosis.—From the description given, it will be seen that the process is a severe one in very many cases, and the prognosis for vision, or it may even be for retention of the eyeball, very serious. Yet cases of a mild type do occur which soon give way to ordinary routine treatment, and leave only a relatively small and not very opaque, but centrally situated, corneal cicatrix, allowing of some useful vision, which may be improved by an optical iridectomy.

Treatment.—If the case be not severe, atropine, with protection of the eye, may cure in a few days. Warm fomentations should not be used, as they rather promote the activity of the diseased process; and the eye should not be bandaged, lest infective discharge be retained in the conjunctival sac. Antiseptic measures should always be employed, xeroform being the application most likely to prove of use. It may be employed either in the form of a strong ointment (gr. xxx ad ℥j) put into the eye, or it may be insufflated on the floor of the ulcer with a powder-blower. The floor of the ulcer may be washed with a solution of sublimate 1 in 5000, or other antiseptic solutions which do not act as caustics, the action of which on the healthy surrounding tissues might be difficult to control. Scraping the floor of the ulcer with a sharp spoon is a useful procedure.

But it is in all respects wiser to deal with these cases, even the apparently mild ones, actively in the very commencement. If, as is so often the case, chronic dacryocystitis be present the lacrimal sac should at once be extirpated (*vide* chap. ix.). At the same time one or other of the following local measures should be employed—the second being the one now most in use.

1. Sæmisch's Method consists in division of the ulcer with a Græfe's cataract knife. Cocaine having been applied, the point of the instrument is entered about 2 mm. from the margin of the ulcer in the healthy corneal tissue, and, having been passed through the anterior chamber behind the ulcer, the counter-puncture is made in the healthy cornea some 2 mm. from the opposite margin of the ulcer. The edge of the knife being then turned forwards, the section is slowly completed. The incision should divide the intensely infiltrated part of the margin in halves. The aqueous humour and hypopyon are evacuated, atropine is instilled, a bandage is applied, and the patient soon gets relief from pain. Every day, until healing of the ulcer is well established, the wound must be opened up from end to end with the point of a fine probe or spatula, the contents of the anterior chamber being

thoroughly evacuated on each occasion, and atropine instilled. The result is that, in a vast majority of cases, the progress of the ulcer is arrested, and healing soon sets in. The little operation should not be delayed long; yet it may be employed with advantage even in late stages of the process. A satisfactory explanation of its curative action has not yet been given.

2. The Actual Cautery at a red heat is a very valuable method of treatment for this ulcer. The infiltrated and undermined margin of the ulcer is the part which should be most thoroughly cauterised; but its floor, if much infiltrated, is also to be dealt with. The application of fluorescin just before the use of the cautery is of much value, as it enables the operator to clearly discern the whole of the diseased part requiring cauterisation. These ulcers demand prompt and active treatment, before the time is passed when treatment can be of any practical use; and the cautery undoubtedly affords the best prospect of aid of that kind. Even the cautery is often ineffectual to arrest the progress of the ulceration.

At the thinnest part of the floor of an extensive serpiginous ulcer it is desirable to make a perforation through the cornea with the point of the cautery; or, when the cauterisation is finished, the cornea may be paracentesed with a broad needle in a sound region beyond the ulcer. The object is to reduce the intraocular tension, and thus promote the nutrition of the cornea.

Subconjunctival injections of a 4 per cent. saline solution are found to assist the cure (p. 218).

Very recently Römer has proposed, and both he and some others have carried out, treatment of the serpiginous ulcer with his anti-pneumococcus serum. For the present it is unnecessary to do more than to mention this method, which is still on its trial.

***Diplobacillus Ulcer.**—This ulcer, which is not very common, bears some clinical resemblance to the ulcus serpens, and may be mistaken for it; but it is less destructive, slower in its progress, and more amenable to treatment. Catarrhal conjunctivitis (p. 137) is usually co-existent, while dacryocystitis is absent, and the history of a trauma is commonly to be obtained. The definite diagnosis can only be made by means of a bacteriological examination of the secretion taken from the floor of the ulcer. In the initial stage, a central, or almost central, grey infiltration, often of very small size, appears near the surface of the cornea, surrounded by a delicate halo of less intense infiltration, and there is marked pericorneal injection. After a few days, the ulcer becomes developed. It is 2 to 4 mm. wide, shallow, and covered with a greyish membranous exudation, which can be lifted off. Occasionally the floor is greyish-yellow, and deep. The margin is often slightly raised, and sometimes undermined. The superficial layers of the cornea around the ulcer are somewhat opaque, with stippling of the epithelium overlying them; and, deeper in the cornea, radiating grey striæ reach into the healthy cornea, often nearly to its margin. Iritis and hypopyon are usually present. The severity of the corneal process in the later stages often alters the character of the conjunctivitis, so that it can no longer be recognised as catarrhal. Occasionally small outstanding infiltrations form in the cornea. The ulcer increases in size by extending all round its own margin, although in some cases this process, as in ulcus serpens, is mainly in some one direction. A neglected case may lead on to destruction of the eye through panophthalmitis.

Treatment.—Atropine. Solution of sulphate of zinc one per cent. as eye drops three times a day, or direct touching of the ulcer with a cotton-wool pencil soaked in the solution, or irrigation with a small syringe. In rare cases the galvano-cautery may be needed.

***Rodent Ulcer** (Mooren's Ulcer).—This is a rare and extremely dangerous form of ulcer of the cornea, and must not be confounded with the serpiginous ulcer. It is not a purulent ulcer. The disease commences as a small—sometimes even pinhead-sized—grey infiltration near the corneal margin, not differing in appearance from many a harmless catarrhal infiltration. This rapidly ulcerates. Other similar infiltrations appear in the neighbourhood and at other parts of the margin, and ulcerate, and the ulcers coalesce into one, of which the advancing margin nearest the centre of the cornea is undermined. The undermined margin under which a fine probe can be inserted, consists of partially necrosed corneal tissue, and presents the appearances of a narrow whitish line overhanging the line of active disease. The cornea beyond the margin of the ulcer is normal. There is very great pain and photophobia in some cases, and in others hardly any. The eyeball is injected. The ulcer does not go deeper than about one-fourth of the thickness of the cornea, and perforation seldom occurs. Occasionally a very small hypopyon is present, and occasionally too there is iritis. Before long the ulcer in its oldest portion begins to be vascularised and to heal, and finally leaves an intense cicatrix behind. Gradually the ulceration creeps round the cornea, and at the same time advances towards its centre, by small infiltrations appearing just inside the opaque margin, and which coalesce and soon break down, while healing is taking place in the oldest portions of the ulcer. This process goes on until, finally, the whole surface of the cornea has been eaten away, and cicatricial tissue substituted for it, its centre being the last place affected, and then vision will have become reduced to finger-counting or to perception of light. The progress of the disease is very slow, many weeks or even some months often elapsing before the surface of the whole cornea has been destroyed, and the ulceration may become stationary for a time, only to start afresh without any apparent reason. Some clearing up of the corneal opacity may subsequently take place, but cannot be reckoned upon. Yet in a few cases fairly good vision has been regained. The disease attacks both eyes in about one-fourth of the cases, although there may be an interval between the onset in each, of weeks, or months, or more. It attacks decrepit people of over middle life, but occurs also in young persons and in those of apparently robust health. Its etiology is obscure. No specific micro-organism has as yet been discovered as the immediate cause.

The onset at the edge of the cornea in the form of small grey infiltrations, the grey and shallow floor of the ulcer, its pale grey or almost white margin, the undermining of this margin (which may readily be ascertained by passing the point of a probe under it), and the steady advance of the ulceration towards the centre and around the edge of the cornea, are the characteristics of this disease.

Treatment.—Rodent ulcer is usually a most intractable disease, and leads to serious loss of vision. The general nutrition of the individual is to be improved, but reliance is mainly to be placed on local treatment, which should especially be directed to the undermined margin, or rather to the surface immediately underlying this, after the overhanging lip has been cut away with fine sharp scissors. The galvano-cautery is much in use here, and it is important that the burning should be rather deep. Pure liquid carbolic acid applied with a fine bit of wood, the excess being taken up with a bit of blotting paper, is also useful. In a case under the care of one of us (H.R.S.) absolute alcohol applied to the ulcer (see p. 238) produced a remarkable and rapid cure, so that a small central area of sound cornea was preserved; and a second case has been similarly cured. Scraping, tincture of iodine applied with a camel's-hair pencil, sublimate lotion, with a bandage and the usual warm fomentations, may help in the treatment. The covering of the diseased part—after it has been well cauterised—or of the entire cornea, with a conjunctival flap, is a measure which may be worth the trial.

***Marginal Ring Ulcer** is a rare form, which commences as a clean-cut, or but slightly infiltrated, yet rather deep, ulcer at the corneal margin. Its tendency is to extend along the margin of the cornea; and in some instances healing takes place in the older parts of the ulcer, while it is still progressive at the newer parts. It may extend all round the cornea, and finally give rise to complete sloughing of the latter by cutting off its nutrition. This ulcer may result in children from a marginal phlyctenular infiltration (p. 200), but is more common in adults, or in aged people, whose nutrition has fallen very low.

Treatment.—The actual cautery. Paracentesis through the ulcer, eserine having been first instilled. Insufflation of xeroform. Warm fomentations. A bandage. Quinine, iron, and strychnine internally, with nutritious diet.

Absorption Ulcer (Facetted Ulcer, Superficial Transparent Ulcer) is the term applied to a certain definite superficial ulceration which is accompanied by but little opacity and by no vascularisation, and which is usually seated at or near the centre of the cornea, where it presents the appearance of a shallow pit about 2 mm. broad, with rounded margin, its floor being covered with epithelium. If the eye be exposed to cold, wind, or other irritation, some circumcorneal injection makes its appearance, and there is lacrimation; but these symptoms soon pass off again. The healing process may take months to be completed, and slight opacity remains. Often the defect is never quite filled up, but a small facet is left, which is liable to interfere with vision.

The absorption ulcer does not tend to perforate, nor to spread over the surface of the cornea.

It occurs chiefly in childhood, and probably indicates malnutrition of the general system; some observers, indeed, think there is a close relationship between it and phlyctenular ophthalmia. It is also seen in granular ophthalmia, with and without pannus.

Treatment consists in atropine, dionine, and protection, with a bandage in the early stages; and the yellow oxide ointment in the later stages. General treatment with suitable tonics is indicated.

***Neuro-Paralytic Keratitis.**—In paralysis of the Ophthalmic Division of the Fifth Nerve purulent infiltration with hypopyon and ulceration of the cornea is occasionally observed, or the process may be very superficial and aseptic. It was formerly believed that the fifth nerve had an influence over the nutrition of the cornea, and hence that neuro-paralytic keratitis is a trophic process; but it has been shown that this is not the case, and that the affection is due to the diminished reflex lid-action and secretion of tears, and consequent drying and disorganisation of the corneal epithelium, which renders it possible even for septic infection of the cornea to take place. This disease, therefore, cannot be regarded as of neuropathic origin in the strict sense of the term.

That keratitis is not very common with paralysis of the fifth nerve, is no doubt due to the moisture of the surface of the cornea being sufficiently maintained through the consensual action of the eyelids of the affected eye with those of the opposite eye; and, also, that reflex lacrimation of the affected eye, although in diminished degree, results from stimulation of the opposite cornea. Yet under certain conditions —*e.g.*, if the nictitation be incomplete (partial paralysis of the facial nerve), or if there be some proptosis—the cornea may become dry, and keratitis may appear. In all the cases published of paralysis of each fifth nerve, keratitis appeared, for here the protection of the reflexes originating on the other side was not present. The absence of any ill-result to the cornea from the operation of extirpation of the gasserian ganglion on one side for severe neuralgia is explained by what has just been stated.

Treatment consists, in the milder cases, in protection of the cornea by keeping the eyelids closed with a bandage, or by fastening them together with a dermic suture. The severer cases of purulent infiltration or ulceration must, in addition, be dealt with on the lines laid down in previous pages for the treatment of those conditions.

***Keratomalacia (Infantile Ulceration of the Cornea, with Xerosis of the Conjunctiva)** is a very rare affection. It attacks some poorly nourished children early in the first year of life, making its appearance at or near the centre of the cornea. Iritis always supervenes in severe cases. That portion of the bulbar conjunctiva which is exposed in the palpebral aperture at either side of the cornea undergoes slight epithelial xerosis, similar to that in functional night blindness, due to retinal exhaustion (see chap. xix.). Sometimes the xerosis of the conjunctiva is absent. Ulceration of the cornea soon comes on, through necrosis of the layers ying over an interstitial infiltration; and this ulceration spreads until it involves the whole of the cornea, except a very narrow margin. Finally, perforation, with prolapse of the iris, and panophthalmitis may supervene.

Both eyes become affected as a rule, although the disease usually attacks one eye some time before its fellow. The atients almost always die of diarrhœa, pneumonia, etc.

Cause.—Streptococci have been found in the corneal ulcer nd in the conjunctiva, while a general streptococcus invasion f the vascular system of the whole body is also present. To the latter circumstance are referred the conditions which ead to a fatal termination. Many of the infants attacked re syphilitic, but whether, as is held by some, the corneal rocess is a specific one, and not merely part of the general achexia, is an open question.

Treatment is of little avail; but warm fomentations and the use of non-irritating antiseptic lotions, etc., are indicated, along with an antiseptic dressing. Such means as may possibly promote improvement of the general system are obviously called for. In cases of congenital syphilis, calomel internally is stated to have been of great service, not only to the general state, but also to the corneal disease.

***Herpes Corneæ Febrilis.**—Not only in herpes zoster ophthalmicus (see chap. viii.), but also in herpes febrilis (or catarrhalis) is a vesicular eruption liable to occur on the cornea. It is met with in any of the inflammatory affections of the respiratory tract, from a common cold, to severe pneumonia. Also with whooping cough, and with intermittent and typhoid fever. It can also occur as a primary affection. It may be of more common occurrence than ophthalmic practice would lead us to think, for it is the resulting ulceration which more commonly comes under our notice. The patient complains of the sensation of a foreign body in the eye, with lacrimation and photophobia, and these symptoms disappear when the vesicles burst.

On the surface of the cornea of one eye is formed a group of clear vesicles, each from 0·5 to 1·0 mm. in diameter. They usually form in a line, which runs obliquely across the cornea, or sometimes in a vertical direction. Now and then they are arranged in trefoil shape or in a circle. The covering of the vesicles is short-lived, and, as already remarked, the resulting ulcer is that which the surgeon usually first sees. Even it, however, is thoroughly characteristic. On the surface of the clear cornea is an irregular loss of epithelium, along the margins of which may still sometimes be seen the shreds of the late covering of the vesicle. The margin of the region which is bared of its epithelium is dentated, and can only be mistaken for a traumatic loss of epithelium. But the latter would not present the peculiar 'string-of-beads' appearance. The floor of the loss of substance is formed by the superficial layers of the cornea, and anæsthesia of the cornea is confined to this place, and does not, as in herpes zoster, extend to the rest of the cornea. The tension of the eye is generally reduced. Under favourable circumstances this loss of epithelium may be rapidly repaired; although even then more slowly than one of equal dimensions, but of traumatic origin. Usually the healing process is slow. Sometimes more or less intense opacities form in the area and at the margin of the ulcer, with hypopyon, iritis, etc., and the loss of substance becomes deep, with a dentated margin. This more unfavourable course is the result of secondary infection of the ulcer.

Treatment at an early stage, before the vesicles have burst or the loss of substance has become infiltrated, consists in protection of the eye, and, when infiltration has set in, in disinfection, with protection. In obstinate cases 4 per cent. saline subconjunctival injections are often of use. If the vesicles give great pain they may be ruptured by dusting a little calomel into the eye, or by brushing it with a camel's-hair pencil wet with solution of boric acid, after which a well-fitting antiseptic dressing is applied. Cocaine should be used as sparingly as possible, owing to its ill-effect on the epithelium when used in excess. Atropine and warm fomentations are indicated, and a weak yellow oxide ointment is of use in some cases. Where the nostrils are affected, weak sublimate or other antiseptic washes should be applied to the Schneiderian mucous membrane.

***Filamentary Keratitis** (Fädchen-Keratitis).—This is very rare. Its name is due to the fine threads, like twisted spun-glass, several of which hang from the surface of the cornea, and give the condition its characteristic appearance. These threads never reach a length of more than 3 or 4 mm., and are composed of twisted proliferating epithelial cells, each ending in a bulbous enlargement caused by degeneration of the epithelium. The condition may result from a superficial trauma of the cornea, or from a bullous or herpetic keratitis.

Treatment.—The instillation of a 3 per cent. solution of chloride of ammonium into the eye every two hours, by which the exfoliation of the epithelial growth is promoted and hastened, produces a rapid cure. Protection of the eye with a bandage is important.

***Bullous Keratitis**.—Bullæ very rarely form on the cornea. They are seldom the primary condition, but usually depend on a diseased process in the true cornea. This process may itself be a primary disease; but more commonly it, too, is secondary to deep changes in the eye, such as absolute glaucoma, iridocyclitis, etc. Very rarely bullæ are seen on the cornea of an otherwise sound eye, in a person whose health is in a debilitated state. Bullæ on the cornea are sometimes caused by blows on the eye, or by direct traumata of the cornea. The formation of a bulla is attended by much pain and photophobia, which disappear as soon as the bulla ruptures. One, or more than one, bulla may form at a time. After a day or two they rupture, and their walls then hang in shreds from the surface of the cornea, and may produce the appearance of filamentary keratitis, and the seats of the bullæ present shallow depressions. These losses of substance heal without leaving any permanent opacity. After an interval of days or weeks another crop of bullæ appears, and runs the same course.

Treatment.—The bullæ should be opened, and their walls snipped away with a scissors, and a bandage applied. The recurrent attacks may cease after a length of time; but so far as treatment can influence them it can only be effected by relieving the process in the cornea which gives rise to them. If it be a primary process, warm fomentations, atropine. and a bandage, with remedies directed to the correction of any fault in the general state of the health which may exist, are suitable; or if, as is more common, a deep ocular process (glaucoma, etc.) be the cause, the recognised treatment for this latter must be adopted.

***Dendriform** (*δένδρον, a tree*) **Keratitis.**—This is a rare affection. It is a very superficial and chronic ulceration, with but little infiltration of its margins or floor, and presents the appearance of a fine groove, or grooves, on the cornea. It spreads chiefly over the central region of the cornea by throwing out branches on either side, while on the end of each branch there is usually a minute grey infiltration, and its true nature may easily be overlooked unless the cornea be examined by the combined focal method. The pain and irritation are sometimes severe, and again but slight or quite wanting. Some slight permanent opacity may remain when cure has been effected.

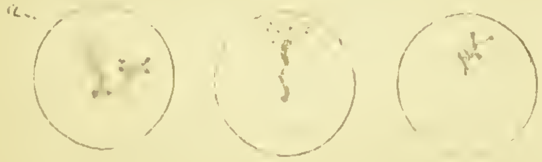


Fig. 115.

Fig. 115 represents three of the most common appearances presented by this disease. At *a* in the left-hand drawing there is a nebula where healing has set in, while in another part of the same cornea the process is in an active stage. In the central drawing, near the upper corneal margin, there is a fine herpetic-like eruption, and a long groove passing down from it. And, in the right-hand drawing, the tendency to branch is well shown.

In cases which have been long neglected, and in which the disease has run riot over the cornea, no healing process having been set up, the surface becomes dull grey and irregular, as though ploughed up, the primary characteristic appearances being lost by reason of the amount of disease present The ulceration rarely becomes septic.

The Cause has not been definitely ascertained, but the peculiar habit of the affection renders it almost certain that it is produced by a mould. The opinion is strongly held by some, that these ulcers result from a herpetic eruption on the cornea.

Treatment.—Scraping with a sharp spoon, with the subsequent application of 1 in 1000 solution of corrosive sublimate to the cornea, is recommended by some, also the application of pure carbolic acid to the ulcer with a fine camel's-hair pencil, care being taken to confine it to the ulcer, and the actual cautery is sometimes useful.

It was in the fourth edition (1892) of this handbook that attention was first directed to the value of the local application of absolute alcohol in this obstinate disease, and since then it has proved in our hands an almost certain, as well as a rapid, cure in nearly every case. A small bit of lint is folded to a point, and the latter is dipped in the alcohol. The ulcerated portion of the cornea is then rubbed with the point with such pressure as to take away the epithelium, and, so far as possible, the rest of the corneal surface is avoided. Or, if a very little cotton wool be rolled round the end of a small fine bit of match wood, and this used instead of the lint, the application may be more accurately confined to the affected part of the cornea. Immediately afterwards the conjunctival sac is freely washed out with sterilised salt solution, to remove all surplus alcohol which would increase the subsequent pain. The application is painful even with cocaine. As a rule there is much pain for some hours afterwards, and for this hot fomentations afford the best relief; cocaine is of little use. Usually one application is sufficient to produce cure, but some cases require it to be repeated after four or five days. It is not desirable to repeat the application more than once, or at most twice, as the corneal epithelium is then liable to become deranged, and filamentary and bullous keratitis may be produced.

The application of a fine point of sulphate of copper to the ulceration also produces some good cures. It is less painful than the alcohol, because its action is easily confined to the ulcerated part, but it does not produce so certain a cure.

* **Keratitis Aspergillina.**—This rare disease was described by Leber. The appearance presented is that of an ulcer from 3 to 5 mm. in diameter, occupying a rather central position in the cornea. The surface of the ulcer is of a pale greyish yellow, and is very irregular. A striking and characteristic appearance is the dryness of this surface, the copious discharge of tears flowing over it without seeming to wet it. The rest of the cornea is slightly opaque and dull, and there is a small hypopyon present. The conjunctiva is injected and swollen, and is covered with some mucous secretion. The eyelids are rather swollen. There is photophobia and often severe pain. Masses removed from the surface of the ulcer and examined with the microscope are found to be full of the aspergillus fumigatus. It may usually be ascertained that an injury has preceded the appearance of the ulcer.

Treatment.—The membranous mass which forms the floor of the ulcer should be peeled off, and the underlying surface cauterised and dressed with xeroform, after which a good and rapid cure takes place.

* **Tubercular Ulceration of the Cornea.** See p. 250.

(b) NON-ULCERATIVE INFLAMMATIONS OF THE CORNEA.

* **Abscess.**—This affection is on the borderland between the ulcerative and non-ulcerative inflammations of the cornea; or in one case it results in an ulcer—usually the ulcus

serpons—while again it runs its course without ulceration. The abscesses which are seated in the more superficial layers are those which go on to ulceration; those in the deeper layers are less likely to do so.

Abscess differs from infiltration in that the pus which forms it destroys the true corneal tissue—the fibrillæ and fixed corpuscles—and does not merely lie between them.

Signs and Symptoms.—The appearance presented is that of a yellowish circumscribed opacity, more intense at its margin than at its centre, seated at or near the middle of the cornea, and surrounded by a light grey zone. It is usually round in shape, but when situated near the edge of the cornea it is apt to be crescentic. The surface of the cornea just over the abscess is at first a little elevated over the general surface, but later on becomes flattened, owing to a falling-in of the normal layers anterior to the abscess; and the epithelium of the flattened part has a dull, breathed-on look. The rest of the cornea may also lose its brilliancy, although in a much less degree. Hypopyon and iritis are constant attendants upon corneal abscess. There is much injection of the conjunctival and ciliary blood-vessels. Severe pain in and about the eye and blepharospasm are common, yet occasionally a corneal abscess will be attended by but little pain or other irritation.

Progress.—The abscess spreads through the cornea, usually in some one direction, and this direction is indicated by the yellowish opacity being more intense at the advancing side of the abscess. Before long, if the abscess be superficial, the layers of cornea covering it come away, and the condition is changed into that of the ulcus serpens already described. The deeper abscesses spread through the cornea more or less widely, and ultimately become absorbed, without having caused ulceration. But even these abscesses leave considerable opacity behind. The process which ends in ulceration is the more common of the two.

Etiology.—Abscess is the result of infection of the cornea with pyogenic organisms, which reach it either from without, through some traumatic loss of substance of the corneal epithelium, or from within, by the agency of the blood. The micro-organisms, which are introduced through a superficial loss of substance, may either have been on the foreign body which produced the injury, or they may have been present in the conjunctival sac, or in the lacrimal sac. Infection through the blood is occasionally seen in some acute exanthematous diseases, such as scarlatina, measles, and smallpox; more especially in the latter in its convalescent stage.

Treatment.—Atropine, warm fomentations, and a bandage. But if these mild measures do not in a day or so arrest the progress of the abscess, resort must be had to the actual cautery.

* **Ring Abscess.**—This term is hardly correct, as the so-called ring abscess is in fact a purulent infiltration of the tissue of the margin of the whole cornea, or it may lie 1 mm. or 1·5 mm., inside the actual margin. It is not a common affection, and is almost always caused by perforating wounds, including operation wounds, at any part of the cornea, and sometimes follows on perforating wounds of the sclerotic. It may also occur after spontaneous perforation of a corneal ulcer, the infection of an old incarcerated iris prolapse, or in metastatic ophthalmitis. Its progress is extremely rapid, leading on to complete necrosis of the cornea and to panophthalmitis within a few days after the perforating injury is sustained, and often rendering excision or evisceration necessary almost as soon as the case comes under observation. In rare instances the process is less violent, and it may then be possible, by means of the cautery and careful dressing, to save some sight, or at least the shape of the eyeball.

Syphilitic Diseases of the Cornea. *Diffuse Interstitial* *or Parenchymatous Keratitis.*—This is by far the most common, and best known, of the syphilitic affections of the cornea. It is most frequently met with between the ages of five and fifteen. It usually commences at some one part of the margin as a light greyish opacity, accompanied by slight injection of the ciliary vessels. The rest of the corneal margin soon becomes similarly affected; and then the opacity gradually extends concentrically into the cornea, or does so by sending in processes which afterwards become confluent. In this way the whole cornea becomes affected by degrees; and its epithelium acquires the breathed-on or ground-glass appearance, which is seen, also, in acute glaucoma. Occasionally the opacity commences at the centre, and not at the margin of the cornea, as small grey spots, and extends towards the margin, which it often does not reach before clearing commences.

The opacity lies in the deep layers of the true cornea, and is slightly more intense in spots here and there. It is sometimes only a very light cloud, while again the cornea may be so opaque as to render the iris quite invisible. Along with the opacity, vessels form in the cornea in its posterior layers, but the degree of vascularisation varies very much in different cases. In some the presence of vessels can only be ascertained by careful examination with a high convex glass (+ 16·0) behind the ophthalmoscope, or with the corneal microscope; while in others the new vessels are present in great numbers, and can be readily seen with the naked eye. In other cases, again, close leashes of vessels follow the tongues of opacity into the cornea, giving rise to the appearance known as the 'salmon patch.' The infinite variety in the degree of opacity and in the amount and arrangement of the vascularisation, results in great variation in the appearances in different cases.

When the whole cornea has become opaque, it begins to clear up at the margin, and the central portion becomes even more opaque than the margin had ever been—a fact which shows that the very cells which entered the cornea at its margin have advanced to its centre. The clear margin gradually increases in width, until only a rather intense central opacity is left. This central opacity slowly breaks up, and becomes absorbed, but not always completely; and then considerable and permanent impairment of vision may remain. Even in the more peripheral portions of the cornea, in some cases, a faint maculated cloudiness may be found on careful examination, years after the active process has ceased.

In severe cases iritis and chorioiditis are nearly always present, although the latter is not observable until the cornea has become clear enough to admit of an ophthalmoscopic examination. The disease, indeed, must be regarded, strictly speaking, as one of the uveal tract, to which the posterior layers of the cornea, which are mainly diseased, belong.

The two forms above described, one commencing at the margin, the other at the centre of the cornea, and more or less vascularised, but for the most part ultimately occupying the entire cornea, are those we are wont to find in children and young adults, and which, as will just now be stated, have congenital syphilis as their usual cause. But in older persons, up to thirty or thirty-five, milder forms of interstitial keratitis are met with. These rarely occupy more than a small region of the cornea, generally towards its centre, either as a patch or as a ring of opacity, and with ittle or no vascularisation.

The affection is often accompanied by a good deal of pain nd blepharospasm, especially in the severe vascular forms, nd there, too, the tension of the eye is apt to be temporarily educed.

The acute stage of the disease lasts from six to eight weeks, or longer. But the entire process may not be completed or many months, and in one case at the Victoria Hospital he opacity did not begin to clear away for eleven months after the cornea was first attacked, the whole process extending over a period of two years.

In children both eyes invariably become affected, although not always at the same time, the onset in the second eye beginning often when the inflammation in the first has made some progress, or, perhaps, when the first eye has undergone cure. It is important, in the very commencement of treatment, to acquaint the patient or his parents with the likelihood of this course of events.

In adults usually one eye alone is attacked, iritis is rare, the duration of the process is comparatively short, and complete clearing up is relatively frequent.

Causes.—The affection is more common in girls than in boys, and most frequently appears during second dentition, when the upper incisors are being cut, or at puberty. It depends upon some serious derangement of the general nutrition; and this, in about 70 per cent. of the cases, is inherited syphilis—a fact which was first pointed out by Mr. Jonathan Hutchinson. The children are often thin, anæmic, and of stunted growth, with flat nose, cicatrices at the angles of the mouth, and are often more or less deaf; and the peculiarities of the incisor teeth, so well known from Mr. Hutchinson's description, are present in about one-half of the cases.

Occurring in adults, the affection is rarely due to inherited syphilis, although acquired lues may sometimes be taken as its cause; while, again, it will often be impossible to assign any origin for it other than the universal one of exposure to cold, etc. Some cases are due to tubercular disease (see p. 250).

Prognosis.—In children—in view of the possibility of an incomplete clearing of the cornea, as well as of the serious uveal complications liable to supervene, and which may completely annihilate vision—the prognosis must be guarded, although by no means hopeless, in those cases where the opacity is very intense, or where there is much vascularity. Yet in the milder cases a favourable prognosis may be given. The affection does very rarely recur.

In adults, as stated, the prognosis is much more favourable.

Treatment.—In the early stages no irritants should be locally applied. Atropine is important for the prevention of iritis or of posterior synechiæ; and the use of radiant heat, in the form of hot poultices or fomentations, or the Japanese warmer, promotes the nutrition of the cornea and hastens the cure by absorption of the cellular elements which form the opacity. Dionine is often very useful. A bandage should be worn. Subconjunctival injections of the oxycyanide of mercury 1 in 5,000, are often useful. When the acute stage is ended, the yellow oxide ointment may be employed with benefit for stimulating the absorbents to carry off what remains of the opacity. Massage may be used with advantage n both stages to disperse the infiltration. In severe cases a course of mercurial inunctions, continued for several weeks, is very advisable; care being taken not to allow stomatitis to exceed moderate bounds. In mild cases a tonic plan of treatment, with iodide of iron and cod-liver oil, is he most suitable.

Counter-irritation, in the form of blisters to the temple or a seton in the scalp, is extensively employed by some surgeons. We do not use this treatment, as we doubt its value, and are loth to add to the worries inseparable from so wearisome disease.

The following much rarer forms of syphilitic disease of the ornea are described:—

* *Specific Punctiform Interstitial Keratitis.*—Circumscribed, pinhead-sized, greyish infiltrations form at various levels in he otherwise clear stroma of the true cornea. They do not grow larger, nor suppurate. They form rapidly, and disappear apidly when cure commences, leaving little or no opacity ehind. The affection is not associated with iritis, but there

is usually some ciliary injection. In somewhat similar cases the punctiform opacities are not so defined but are surrounded by a halo of lighter opacity, and iritis is present. This affection is a manifestation of tertiary syphilis, and the punctiform opacities have been regarded as the products of a gummatous inflammation. The treatment would be iodide of potash internally, and locally atropine, warm fomentations, and a bandage.

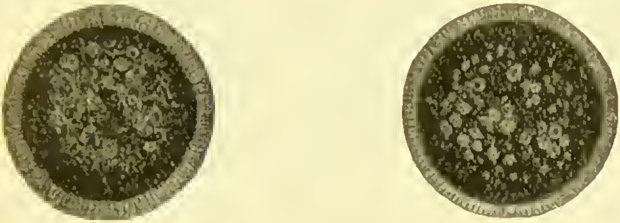
* *Gumma of the Cornea.*—Some cases of true gumma of the cornea have been recorded. The growth appears as a pale grey or whitish elevation, more or less vascularised, on the cornea. The diagnosis depends very much on the patient being the subject of tertiary syphilis. The treatment is iodide of potash.

* *Keratomalacia* is also reckoned by some to be a syphilitic affection (see p. 233).

* **Keratitis Profunda.**—This presents the appearance of a greyish opacity in the deep layers of the cornea at or near its centre, which gradually increases in intensity and extent, but never reaches the margin of the cornea. The epithelium of the cornea over the infiltration is dull and stippled. There is but little vascularisation, and no great tendency to inflammation of the uveal tract. After some weeks the infiltration gradually breaks up and becomes absorbed, leaving in severe cases a good deal of opacity, and in less severe cases a fairly clear cornea. The affection is seen only in adults, and its etiology is unknown, but rheumatism, malaria, and traumatism have been held accountable for it. It seems probable that it is the result of a localised derangement of the posterior epithelium of the cornea; but if that be so, the ultimate cause of that derangement has not yet been suggested.

Treatment.—Atropine, warm fomentations, dionine, subconjunctival saline injections, and bandage, with care of the general health.

* **Guttate or Nodular Keratitis**, and **Grating-like or Reticular Keratitis.**—These were originally described as separate diseases by separate observers, but it is now recognised that they are essentially one and the same disease, and that merely an unimportant difference in the form of the appearances presented by the cases exists. This nodular or reticular keratitis—a satisfactory title is wanting—is a rare disease. Its presence is apt to be overlooked in the early stages; for by focal illumination the cornea may seem perfectly normal, and the rest of the eye, except perhaps or some slight distension of the anterior ciliary and larger conjunctival vessels, is healthy, and the eye is free from irritation. The patient merely complains of slight burning sensations, especially during use for near work, of some hotophobia, and of somewhat diminished acuteness of vision. Transmitted light from the mirror displays in the illuminated pupillary area of the cornea a number of small paque patches of all shapes, occupying the most central position, while between them, and sometimes reaching out more towards the periphery of the cornea, but often leaving clear zone inside its margin, innumerable very fine dots are present—nodular keratitis. In some cases the opaque patches are absent, while a number of fine forked lines are seen in the early stage outside the central region, which at first is occupied by fine dots alone. At a later period, the arrangement of the radiating forked lines assumes a somewhat reticulated appearance, like that of a grating, and they



IG. 116.—Nodular Keratitis. Mr. W. J. Hancock's case. *Trs. O.S.* xxv.

extend to the centre of the cornea—reticular or grating-like keratitis (gitterige keratitis). The corneal microscope shows that these dots, patches, and lines are greyish, and situated close under the epithelium. The surface of the latter is, in the early period, in no way altered. Gradually the diseased appearances increase in amount, the anterior ciliary vessels become more distended, vision sinks lower, and the patient may sometimes complain of slight pain, with lacrimination, and swelling of the eyelids; but more commonly there is no irritation. The lines, dots, and patches now begin to show slight elevations on the cornea, although covered by epithelium. At a still later period the opacity in the centre of the cornea becomes more intense, a marginal zone of the cornea remaining fairly clear. At this stage the diagnosis may again become doubtful, owing to the amount of the disease which obscures the characteristic appearance. Both eyes are always affected, either simultaneously, or with a short interval. The disease is exceedingly intractable and chronic, lasting many years, and finally causing much loss of sight. Most of the cases observed have been in young adult males, and it often attacks more than one member of a family, in one or in succeeding generations—it is, in fact, one of the family diseases. No relation to syphilis or other constitutional disease has been made out, although Wehrli has raised a strong suspicion that it is a tubercular malady, and even calls it lupus of the cornea.

Treatment.—Treatment, so far, has proved of little, if any, benefit. Yellow oxide of mercury ointment, warm fomentations, galvanism, and hydrate of chloral eye-drops have been used. The more modern methods with dionine and subconjunctival injections should also be given a trial. And, if the disease is to be regarded as tubercular, treatment with tuberculin T.R. is indicated.

* **Discoid, or Annular, Keratitis** (Keratitis Disciformis,

Fuchs).—This disease occurs for the most part in persons of middle age, and frequently commences with slight defects of the epithelium caused by traumata or by herpes. It has also been seen by Schirmer in connection with vaccine vesicles on the eyelids or conjunctiva. It is characterised by a delicate grey disc which is situated deeply in the true cornea, at or near its central region, and which is marked off sharply all round from the normal peripheral portion of the cornea by a more intensely narrow grey margin or ring; or, outside this ring, there may be another or even two more peripheral rings, all concentric with each other. With the corneal microscope grey striæ can sometimes be seen in the opacity, which may radiate out into the clear cornea, parallel with each other or crossing at various angles, similar to those which occur in some other keratitides. The surface of the affected region is dull and its sensation diminished. In the course of the malady, which may run over several months, slight superficial ulcerations occur, and finally a rather intense opacity is left at the seat of the disease. The uveal tract is not usually implicated, but in rare instances the presence of some punctate deposits may be detected.

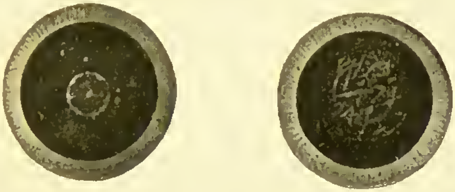


FIG. 117.—Forms of Discoid Keratitis (After Schirmer).

Treatment is of little avail. It should consist in atropine, bandage, hot fomentations, subconjunctival saline injections, and dionine.

* **Tubercular Keratitis.**—Tubercular disease of the cornea presents itself in several forms:—

1. Pale yellow nodules which appear at the corneal margin, extend to its deep, but not to its deepest, layers, and protrude slightly over its surface, accompanied by ciliary injection. These nodules advance towards the centre of the cornea, become confluent, and finally undergo absorption, leaving an intense opacity behind; or they may break down into ulceration, which may occupy most of the corneal surface. The ulcer never perforates, and after a time healing takes place with cicatricial opacity, which may clear up to a great extent. This is the only truly primary form of tubercular disease of the cornea, no other part of the eye being affected, and it is rare. In the other forms of tubercular corneal disease the process is propagated to it from neighbouring parts.

2. Diffuse interstitial (or parenchymatous) keratitis. In about 70 per cent. of the cases of this affection congenital syphilis is recognised as its cause (p. 244). It is now held that of the 30 per cent. which remains most, if not all, of the cases depend on tubercle, but without the presence in the cornea of tubercular nodules. Tubercular disease of the anterior uveal tract (see chap. xi.), co-exists; and, presumably, the corneal affection is the effect of toxines diffused in the cornea from the angle of the anterior chamber. This form is capable of complete retrocession.

3. Greyish sclerotising opacities caused by tubercular nodules, which grow into the corneal margin in its deepest layers from the ligamentum pectinatum. These opacities occur at several parts of the periphery of the cornea; and, by throwing forward tongues, they slowly spread into the cornea. Although the process may cease at any point, the cornea remains very opaque at the parts attacked, with resulting disfigurement or loss of sight.

4. Miliary tubercular nodules may form in the cornea in connection with tubercular episcleritis at the corresponding portion of the corneal margin, and may spread further into

the cornea. These nodules do not ulcerate, and ultimately disappear leaving opacity behind.

5. Pannus, ulcers, and granulations, as the result of tubercle of the conjunctiva. The ulcers sometimes perforate. In the scrapings from tubercular ulcers the tubercle bacillus may be found.

Treatment.—For tubercular ulceration, curetting, with the insufflation of xeroform, or, should these fail, the cautery. For the other forms tuberculin T. R. is indicated (see chap. xi.). Guaiacol and creosote have been used internally.

* **Keratitis Punctata.**—Until recent years this term was only given to a condition which occurs in cyclitis, in iridocyclitis, and in sympathetic ophthalmitis, and which is not a primary disease of the cornea, and therefore does not come within the scope of this chapter. It will be considered under those headings (chap. x.); and it need only here be stated that it consists in the deposit, in the form of fine dots on the back of the cornea, of lymph derived from inflamed portions of the uveal tract, mainly from the inflamed ciliary processes. For it the term punctate deposits is to be preferred to keratitis punctata.

Fuchs has described a form of keratitis which he terms *Keratitis punctata superficialis*, and which has a good claim to that name. It begins with the symptoms of an acute conjunctivitis, but there is decided pericorneal injection, while the conjunctiva is not much injected, nor is the discharge mucous or purulent, but is rather an abundant lacrimal secretion. There is photophobia and pain. Either at the same time, or some days or weeks afterwards, minute grey spots may be seen in the superficial layers of the cornea, the epithelium over the spots being somewhat raised up, giving a dull appearance to the corneal surface. The spots are often arranged in groups or rows, and may be scattered over nearly the entire cornea, or else confined to its central region. There may be but a few of them, or there may be a hundred or more, and one or both eyes may be affected. The initial irritative symptoms soon disappear; but the spots themselves remain for many weeks, or longer, and finally fade away completely. The disease is more common in young people than in later life, and occurs usually in connection with a catarrh of the air passages; but it must not, by reason of this, be confounded with herpes of the cornea. One or both eyes may be attacked. The spots are often very faint, and hence can easily be overlooked, unless searched for with the combined focal method. In this country the affection is rather rare, but several cases of it have come under our notice.

The Treatment should consist in atropine, bandage, and warm fomentations.

* **Sclerotising Opacity** of the cornea sometimes complicates scleritis, affecting the margin of the cornea in the neighbourhood of the scleral affection, but not extending more than 2 to 3 mm. into the cornea, except in very severe cases. It is an intense white opacity situated in the true cornea, and is apt to remain as a permanent opacity, even when the scleritis undergoes cure. In such cases of sclero-keratitis iritis is often present.

Treatment.—Atropine, warm fomentations, massage, subconjunctival saline injections, and the treatment of whatever constitutional derangement of health (rheumatism, syphilis) may be held to have given rise to the scleritis.

Ribandlike Keratitis (Transverse Calcareous Film of the Cornea; Calcareous Film of the Cornea).—This is a degenerative alteration which occurs chiefly in the corneæ of eyes destroyed by severe intraocular processes, such as iridocyclitis, sympathetic ophthalmitis, glaucoma, etc.

It also occasionally occurs as a primary disease in some persons of advanced life. In these latter instances glaucoma often comes on at a later period, or the corneal disease may be followed by irido-cyclitis, or central chorioiditis. It seems probable that, in these primary cases, the cause of the degeneration is simply a loss of vital energy in the corneal tissue, due, it may be, to vascular changes.

The disease occupies that transverse strip of the cornea which is uncovered in the commissure of the eyelids during waking. It usually commences on the inner margin of the cornea, but soon appears at the outer margin, and advances from each direction towards the centre, where the two sections join. It presents the appearance of a greyish-brown opacity, with, in most cases, white calcareous deposits in and under the epithelium. In blind eyes which are constantly rolled upwards, the opacity is found, not in the central transverse section of the cornea, but in the exposed lower third. The opaque masses consist of carbonate and phosphate of lime. Leber puts forward the view that an abnormally abundant supply of phosphate of lime in the blood, and nutritive fluid of the cornea, is the cause of this condition, the rapid evaporation on the exposed part of the cornea being the reason why the deposit takes place there. The deposit is at first in Bowman's membrane, but later on it may appear in the anterior layer of the true cornea, and in the epithelium.

Treatment.—Some improvement may be effected by scraping away the chalky deposit.

ECTASIES OF THE CORNEA.

Staphyloma of the Cornea is the result of a perforating ulcer of the cornea. In foregoing pages the methods for obviating, so far as possible, the occurrence of corneal staphyloma have been set forth. The ulcer, having healed, may present a weak cicatrix, which becomes bulged forwards by even the normal intraocular tension (Figs. 118 and 119). If the iris be not incarcerated in this cicatrix the anterior chamber will be made deeper (Fig. 119).

Staphyloma corneæ, in which the iris is incarcerated, is probably a more common condition than the above. When a corneal ulcer is large, a correspondingly large portion of iris is liable to become prolapsed into it, and to form a bulging mass. This may burst and collapse, and a flat cicatrix may be formed; or, if it do not rupture, it may form what is termed a partial staphyloma of the cornea and iris, the latter becoming consolidated by the formation of a layer of connective tissue over it.

If the whole, or a very large part, of the cornea be destroyed by an ulcer, the iris is completely exposed. It soon begins to be covered with a layer of lymph, which gradually becomes converted into an opaque cicatricial membrane. Should this not be strong, the normal intraocular tension is sufficient after a time to make it bulge; or, increased intraocular tension may arise in consequence of further changes within the eye, and then bulging of the pseudo-cornea all the more surely comes on, and the condition is termed total staphyloma of the cornea, although obviously the term is somewhat strained, as in fact there is no cornea. Sometimes a total staphyloma has a lobulated appearance, owing to the pseudo-cornea having some of its fibres stronger than others; and hence the name given to the condition (from σταφυλή, *a bunch of grapes*), and which has in time become applicable to almost any bulging of the cornea or

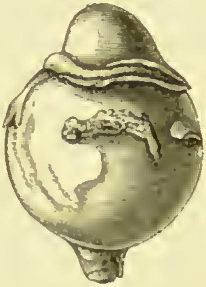


FIG. 118 (*Pagenstecher*).

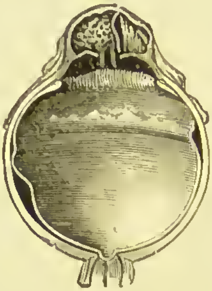


FIG. 119 (*Pagenstecher*).

sclerotic. Such staphylomata are apt to gradually increase to a very large size.

Treatment.—In cases of partial staphyloma, where a clear portion of the cornea remains, an iridectomy is frequently indicated for the reduction of the tension—so that further bulging may be arrested—as well as for the sake of the artificial pupil, which may improve sight, in cases where the normal pupil is obliterated by corneal opacity.

When, sight having been lost, the staphyloma is very prominent, or when total staphyloma is present, enucleation of the eyeball, or one of the following operative measures, must be adopted.

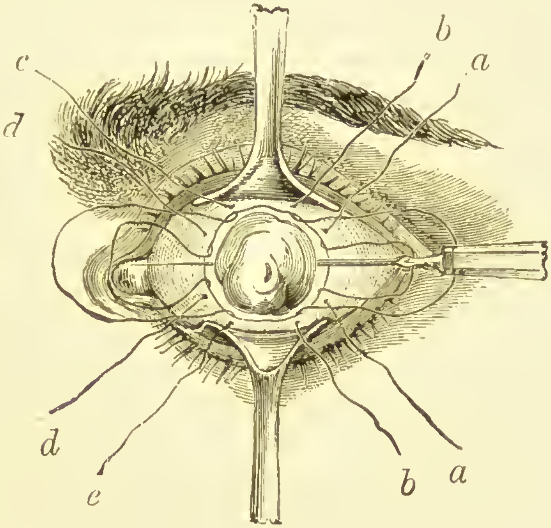


FIG. 120.

Abscission.—A Beer's cataract knife being passed through the base of the staphyloma, with its edge directed upwards, the upper two-thirds of the staphyloma are separated off, while the remaining third is detached by means of a scissors. If the lens be present it must now be removed. The wide opening becomes filled up with granulations, and becomes cicatrised.

In de Wecker's method the opening is closed with conjunctival sutures. The operation is commenced by separating the conjunctiva all round the margin of the cornea, and by then loosening it from the eyeball nearly as far back as the equator. Four sutures (*a*, *b*, *c*, *d*) of different colours are then passed through the conjunctiva about 2 to 3 mm. from the margin of the wound, as represented in Fig. 120. In order to keep the field of operation clear, the ends of two of these sutures are laid over on the nose, while the others are laid over on the temple. The staphyloma is now abscised, and the sutures drawn together and tied.

The foregoing and other methods of abscission are only applicable where the tension is either low or normal. If it be high, the liability to intraocular hæmorrhage during the operation makes enucleation, evisceration, or Mules' operation more suitable proceedings. Indeed, probably most surgeons would now employ one of the two latter operations in all these cases.

Evisceration was proposed about the same time by Græfe, of Halle, to obviate meningitis after the removal of suppurating globes; and by the late Mr. Mules, of Manchester, chiefly to take the place of enucleation in cases of sympathetic ophthalmitis. Many surgeons are opposed to its employment in these latter cases, but for staphyloma of the cornea it cannot meet with any such opposition.

The cornea is removed by making an incision with a Græfe's knife, so as to include one half of the corneo-scleral margin, and by completing the circumcision with scissors. All the contents of the globe are then evacuated by means of Mules' scoop, care being taken to remove the chorioid unbroken by carefully peeling it from the sclerotic margin backwards, until it is only held at the lamina cribrosa. The scoop is then used to lift out the separated unbroken chorioid and the other contents of the globe.

Finally, the margins of the sclero-conjunctival wound are drawn together with a few points of suture. The whole proceeding should be done with strict antiseptic precautions, chief among which is the free use of irrigation with a 1 in 5000 solution of corrosive sublimate before, during, and after the operation, the interior of the globe being most carefully washed out with the solution in a full stream. The result is a fairly good and freely movable stump for the application of an artificial eye.

* *Mules' Operation.*—This proceeding—a modification of the foregoing—was also proposed by Mules for cases of threatened sympathetic ophthalmitis, and, like simple evisceration, has not yet met with universal acceptance in those cases, because many fear that it does not afford sufficient protection against sympathetic ophthalmitis. We do not participate in this feeling. In cases of staphyloma, however, and in some other conditions where the questions of sympathetic ophthalmitis, or of a new growth in the eye to be operated on, do not enter into consideration, no proceeding s more satisfactory, at least in young persons, than this beautiful one of Mules'. The prothesis it gives is almost perfect. Its object is to provide a still better stump for the artificial eye by the insertion into the scleral cavity of hollow glass sphere. It is performed as follows:—

The cornea is removed—the conjunctiva having first been freed from the scleral edge towards the equator of the eyeball—and the contents of the eyeball evacuated, as in simple visceration. The opening is now enlarged vertically, to dmit of the introduction of one of the glass spheres. This ntroduction is best effected by means of a special instrument esigned for the purpose by Mules. The spheres are made n several sizes to suit different cases, and it is well not o use the largest which will fit into any given eye. The phere having been inserted, the margins of the sclerotic pening are united vertically by some points of interrupted uture, for which purpose silk or hemp is preferable to catgut, as the latter is apt to undergo absorption before complete union has taken place. The conjunctival opening is then closed by another set of sutures placed at right angles to the sclerotic line of closure. Similar antiseptic precautions are required, as in simple evisceration, and all bleeding should have ceased in the cavity before the glass sphere is inserted. Before the lids are closed the anterior surface of the globe is well covered with boric acid or xeroform. A firm antiseptic bandage is applied. The eye is not dressed for forty-eight hours, and subsequently once every twenty-four hours, using the sublimate solution freely. There is generally some reaction, consisting of chemosis, swelling of the eyelids, and pain, and sometimes these symptoms are very marked, especially if too large a sphere have been employed. In the course of a week or so this all passes off, and a very perfect stump is obtained.

The danger that the glass sphere may be broken by a blow upon the eye has been put forward as an objection to this method. No doubt it is an accident which may occur, and would then necessitate the enucleation of the eye; but no case of the kind has as yet been recorded, although the operation has been in use for more than twenty years. Silver spheres, instead of those of glass, have been sometimes employed to obviate the danger referred to.

We recommend this procedure, and use it frequently. With a well-fitting glass eye, the cosmetic result it gives is infinitely better than that produced either by complete enucleation or by evisceration of the eyeball. It is more uniformly successful in young people than at more advanced ages, and therefore it is better not to use it in persons over twenty-five. To ensure success it is an important point that the glass globe be not too large—it should be an easy fit for the cavity of the sclerotic. In case the sutures give way, and the sclerotic opening gapes, an attempt may be made to reclose it with new sutures, but this is not often ccessful. As a rule the glass globe must in that event e removed, and the case then becomes one of simple visceration.

* *Frost's Operation.*—Mr. Adams Frost, with the object of curing the safety of complete excision, with the cosmetic dvantages of Mules' operation in cases of intraocular rowth, and in cases in which sympathetic ophthalmitis is eared, has suggested the following proceeding.

The eyeball is excised in the usual manner. Immediately he globe has been removed, firm pressure is made for a inute or two with a pledget of wool to arrest all bleeding. Mules' sphere is then inserted into the capsule of Tenon, nd the conjunctiva is instantly brought together and held ver the sphere with forceps, while the sutures are introuced. Three sutures are generally sufficient, and care ust be taken to insert them sufficiently far back to avoid ny risk of their cutting out. In performing the operation he chief point is to lose no time in introducing and fixing e sphere, otherwise blood becomes extravasated into the ssues, the introduction of the sphere is rendered difficult, nd it is liable subsequently to escape. In the earlier perations Mr. Frost picked up and sutured the muscles, t he found that time was thus lost, while there was no mpensating advantage. If the operation is performed in e manner described, the muscles attach themselves to the vering tissue and a very movable stump results. The tures may be left in a week, and the dressing and aftereatment are the same as for Mules' operation. Occasionally the conjunctiva fails to unite over part of the und, the opening then usually enlarges, and the sphere capes. If this should occur, the tissues fall together and e conditions are then the same as after an ordinary cision, and more favourable, Mr. Frost thinks, than after unsuccessful Mules', in which, in his experience, the era often slowly sloughs away. Attempts to close an opening exposing the sphere have not in Mr. Frost's hands been successful. He finds that, if the tissues unite over the sphere, they do not often subsequently give way, although no doubt this happens more frequently than after a Mules'.

* **Conical Cornea**, or **Keratoconus.**—In this condition the cornea is altered in shape to that of a cone, as represented in Fig. 121. If the apex be touched with a probe its extreme thinness may be ascertained. The cornea remains clear, except sometimes just at the apex of the cone, where a slight nebula may be present. The position of the apex of the cone is usually not quite central, and is then most commonly either in the lower outer, or lower inner, quadrant of the pupil. The condition is easy of diagnosis in its advanced stages by mere inspection of the cornea, especially in profile, but in its commencement it may not be so readily detected.

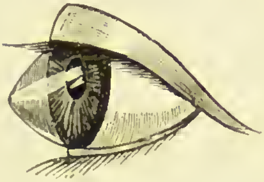


FIG. 121.

In the early stages, when the light is thrown on the cornea from the ophthalmoscope mirror, the corneal reflex will be noticed to be smaller at the centre, owing to the greater curvature there, and a dark shadow, circular or crescentic in shape according to the incidence of the light, appears between the corneal margin and the corneal centre. When the fundus is examined its details will be seen distorted.

In some extreme cases, the patient observes a pulsating alteration in the size of the objects looked at. This is due to the pulsation of the apex of the cone, imparted to it by the intraocular circulation, and comparable to the pulsation of an unclosed fontanelle of the skull. Objectively the pulsation can be seen with the corneal microscope.

On examining the cornea with the keratoscope[1]

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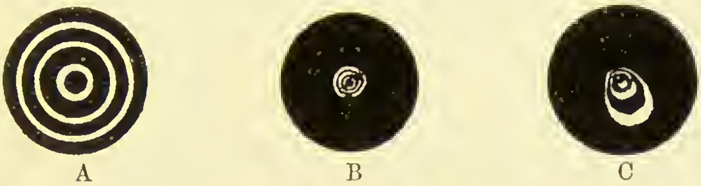
[1] The keratoscope is a disc made up of concentric black and white circles. These circles are not equidistant, but their radii are calculated according to the law of tangents, so that, when reflected on a normal spherical cornea, they appear in the image to be equidistant.

(Placedo's disc) the corneal reflex, instead of being normal, as at A (Fig. 122), is altered as at B or C.

With the astigmometer, the portions of the images on the apex are smaller and overlap, while the more peripheral portions may only touch, or may even not come into contact.

The process begins in early adult life, progresses slowly, never leads to rupture or ulceration of the cornea, and, finally, after many years, ceases to progress, but does not undergo cure. Both eyes are apt to become attacked, one after the other. The disturbance of vision is very great, owing to the extreme irregular astigmatism produced.

The change is due to a gradual and slowly advancing trophic process in the cornea, at or near its centre, in consequence of which the normal intraocular tension acts on so as to distort it into the conical form. The pathogenesis of the condition is not clearly understood. By ome it is held to be due to congenital weakness at the entre of the cornea, as the result of mal-development, hile others explain it by a chronic degeneration of the embrane of Descemet.



IG. 122.—A, Reflected image on normal cornea. B, Reflected image at apex of cone in conical cornea. C, Reflected image slightly eccentric in conical cornea.

Treatment.—In the early stages, or in slight cases, an provement in vision may be obtained by means of concave pherical or sphero-cylindrical glasses; for, as is evident, e change in shape of the cornea must cause the eye to ecome myopic. The refraction of the central portion of the ornea may be ascertained by retinoscopy, with the aid of a stenopæic disc in the trial frame. At a later period these glasses are of little use. Hyperbolic lenses have been employed, but, although they may raise the acuteness of vision, there are obvious difficulties in the way of the practical every-day use of them. A stenopæic slit renders assistance in some cases, especially in reading.

A few cases are reported in which the keratoconus was much reduced and vision greatly bettered by instillations of eserine, and the application of a pressure bandage, continued for several months.

But it is upon operative measures, with the object of flattening the cornea, that we must chiefly rely for any practically useful improvement in sight.

Von Græfe's Method consists in the production of an ulcer on the apex of the cone, and the resulting cicatricial contraction. From the surface of the cornea, a little to one side of the apex of the cone, a morsel of corneal substance is removed with a cataract knife, care being taken not to open the anterior chamber. On the second day after this proceeding the wound is touched with mitigated lapis (solid), and this is repeated every third day for a fortnight or three weeks. Paracentesis of the anterior chamber is then performed through the floor of the ulcer, and the aqueous humour is evacuated every second day for a week, after which the healing process is allowed to take its course. A bandage must be worn during the whole course of the treatment. Finally, when the contraction and consequent flattening are completed, a narrow optical iridectomy may be necessary, in consequence of the central, or almost central, and rather intense corneal opacity.

Sir William Bowman's Method consists in cutting a disc on the apex of the cornea, but not through its whole thickness, with a small trephine, and in then dissecting off this disc with forceps and cataract knife. Cicatrisation of the wound produces the desired flattening of the cone.

Mr. Stanford Morton employs a modification of an operation described by Mr. Higgens. He excises an elliptical piece from the apex of the cone by transfixing it from above downwards, about midway between its base and apex, with a long narrow rigid Græfe's knife, of which the edge is directed forwards and inclined slightly to the right. The knife is pushed onwards until it cuts its way out a little to the right of the apex of the cone, the aqueous escaping at the same time. The flap thus formed is then lifted up well by a fine forceps, and the knife—with its edge now turned to the left—is passed beneath the points of the forceps, and by cutting forwards the flap is excised. The sides of the wound should be steep and incline towards each other at an angle of 30° to 45°. The apex of the cone being usually somewhat downwards and inwards, or outwards, from the centre of the cornea, it is important, in order to prevent an anterior synechia, to avoid carrying the incision too far downwards. The eye should be well soaked with atropine, both before and after the operation, and a firm compress kept on for some time after the wound has healed.

Multiple puncturings of the apex of the cone with a fine cataract needle have been employed. The summit of the cone is transfixed from three to six times at each sitting, and this may be repeated at intervals of two weeks or more. The first effect of the punctures is to allow some of the aqueous humour to escape, and then the eye is firmly supported with a bandage. The pupil is kept under the influence of eserine. Eventually a network of cicatricial tissue forms, which flattens the cone without giving rise to much corneal opacity.

A satisfactory proceeding, and the one now most commonly adopted, is the application of the electro or thermo-cautery at a red heat to the apex of the cone. By this means a contracting cicatrix is produced, which brings about a general flattening of the cornea, while the operation is practically free from risk. The cauterisation must be strictly confined to a small area at the apex of the cone, and the cornea should not be perforated with the cautery. The operation may be repeated over the same area at intervals of ten to fourteen days, to bring about a more intense cicatrix.

Sir A. Critchett lays much stress on the graduated application of the cautery. He first applies the cautery at a black heat to the whole area intended to be cicatrised; within this area a little more is destroyed at a slightly increased heat, while the very apex is touched with a cautery at a dull red heat. One sitting is sufficient.

After the cicatrisation following on cautorisation is completed, the scar is to be tattooed, and an optical iridectomy will usually be required, especially if the cone has been quite central. The cases in which the apex of the cone has an eccentric position are those most benefited by cautorisation, because the resulting scar interferes less with vision than where it is central.

TUMOURS OF THE CORNEA.

* Primary tumours of the cornea are extremely rare. Epithelioma and sarcoma have their origin not in the cornea, but in the limbus conjunctivæ (p. 196). Dermoid tumours are usually seated partly on the conjunctiva and partly on the cornea (p. 193). Yet a very few cases of papilloma, epithelioma, and fibroma are recorded as taking their origin in the cornea. Corneal cysts also occur.

INJURIES OF THE CORNEA.

Foreign Bodies in the Cornea, such as morsels of iron, stone, coal, etc., are amongst the most common of all accidents to the body. The pain caused by these foreign bodies is very considerable, as can be understood, when the rich nerve-supply of the surface of the cornea is considered.

The dangers which may follow on the presence of a foreign body in the cornea depend partly upon the infection or non-infection of the foreign body, and partly upon the depth at which it is buried in the cornea. The deeper a foreign body lies the more difficult will be its removal, and the greater must be the laceration of the cornea caused by that proceeding. A foreign body which carries infection will be more likely to set up serious inflammatory reaction than one which is aseptic or nearly so. For this reason it is important to ascertain, if possible, the origin of the foreign body, although an apparently aseptic origin must not set all fear on this point at rest. Atoms of hot metal are from their temperature aseptic.

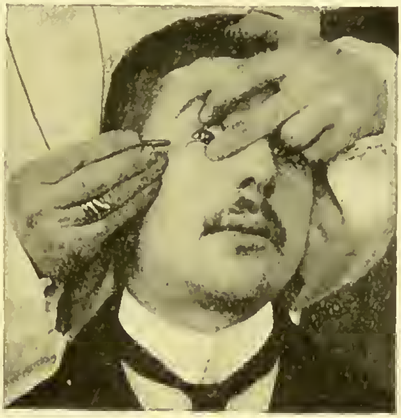


FIG. 123.

Many foreign bodies are so small as to defy detection, until the cornea is searched with the oblique illumination—an aid which should always be made use of, when the symptoms or history in the remotest way suggest the presence of a foreign body.

A foreign body which lies quite superficially in the epithelium is easily removed by gentle wiping with a clean camel's-hair pencil, or soft cloth. Those which lie deeper require instrumental interference, in the following manner :—

The eye having been thoroughly cocainised, the patient is seated, and leans his head against the chest of the surgeon, who stands behind him (Fig. 123). With the index-finger of the left hand the surgeon then lifts the upper lid of the injured eye, pressing the margin of the lid upwards and backwards, while with the second finger he depresses the lower lid in a similar manner. By this means the eyelids are held open, and also, to a great extent, the motions of the eyeball are controlled. The foreign body is now to be pricked out of the cornea with a special needle, with as little injury of the general surface as possible, the patient all the while directing his gaze steadily at some given point. If the foreign body be deep in the layers of the cornea, it must be dug out, as it were; and a minute gouge is made for this purpose. In the case of a morsel of iron or steel which has lain for some time in the cornea, a small ring of rust will be seen surrounding the late seat of the foreign body after its removal. This rust-ring is in the true cornea, and must be carefully scratched away, or the recovery, by necrosis of the affected part, will be much slower, and the resulting opacity much greater.

Care must be taken not to infect the cornea in the removal of a foreign body, and consequently thorough aseptic precautions, especially as regards the instrument used, must be taken. After the foreign body is removed, the place where it was seated should be washed with a 1 in 5000 solution of corrosive sublimate. A bandage is worn until the epithelium is regenerated—*i.e.*, for a day or two.

The magnet is of no use for the removal even of superficially seated foreign bodies of steel or iron in the cornea.

Sometimes a foreign body in the cornea will be long enough to protrude somewhat into the anterior chamber, and there is danger that, in the attempts at removal, it may be pushed farther on, and fall into the anterior chamber. Here it is necessary to pass a keratome through the cornea, and behind the foreign body, so as to provide a firm base against which to work, or the keratome may be made to push the foreign body forwards.

The wing-cases of small beetles and scales of seeds may get into the eye, and adhere to the cornea by their concave surface for several days.

Simple Losses of Substance, or **Abrasions,** of the surface of the cornea, involving the most anterior layers of the true cornea, or perhaps merely the epithelium, are very common from rubs or scratches with branches of trees, finger-nails, etc., etc. These injuries heal readily if the eye be protected with a bandage; but, when neglected, or if septic matter have been introduced when the injury occurred, or if it be present in the conjunctiva or lacrimal sac, these losses of substance are capable of forming the starting-point of corneal abscess (p. 239), ulcus serpens (p. 224), etc.

* A remarkable condition known as **Recurrent Abrasion,** or **Disjunction of the Cornea** (and also as Traumatic Keratalgia, and Recurrent Traumatic Keratalgia) is sometimes observed to follow upon abrasions of the cornea. Healing of the primary lesion having taken place in an apparently normal manner, the patient, after an interval of days, weeks, or even months, on awaking in the morning, is seized with severe pain, similar to that experienced on the occasion of the injury. On examination of the eye a loss of the epithelium, which may be greater or less in extent than was the primary loss, is found at the seat of the original lesion, or, what is remarkable, it may have taken place elsewhere on the cornea. Or, more rarely, instead of a loss of epithelium, the latter may be raised up like a vesicle, or bulla. Examination of such cases has shown that the epithelial covering of a great part of, or of the whole of the cornea may be easily lifted off with a forceps; in short, that the cohesion between epithelium and Bowman's membrane far beyond the immediate seat of the original lesion has become imperfect. Care of the eye by means of a bandage enables the renewed loss of substance to be rapidly repaired; but, after a period of quiescence, another attack takes place on awaking in the morning, or in the course of the night, and such attacks may continue to recur, even for several years. It is characteristic of the

affection that the attacks always take place on awaking—a circumstance which is explained by the slight adhesion between palpebral conjunctiva and corneal epithelium formed during sleep, so that on the lifting of the eyelid the loosened epithelium is torn away, or lifted in a bulla-like shape. There is some loss of sensation of the surface of the cornea. After one of these attacks, examination of the corneal surface by the usual methods may fail to reveal the presence of a loss of substance, and then it may be discovered by means of transmitted light from a plane mirror, which will display the defect as a black mark. The corneal microscope, too, is useful here.

The cause of disjunction of the cornea has not been definitely ascertained. The view has been put forward, and there is good evidence in support of it, that the affection is due to a very slight degree of œdema of the cornea of neurogenic origin, a derangement of the peripheral endings of the fifth nerve in the cornea having been produced by the original injury.

Treatment.—Cocaine, owing to the disorganising effect it has on the corneal epithelium, is to be used as sparingly as possible. A carefully applied bandage is important, and should be worn for long—it may be weeks—after the recurrent lesion seems to be quite well. An operative measure—namely, the removal with the forceps of the entire corneal epithelium or as much of it as easily comes away, is very effectual. The denuded region is soon again covered over with epithelium, and this new growth adheres in a healthy manner to its bed. Some surgeons remove the loosened epithelium with a camel's-hair pencil moistened with chlorine water, and others take it away with a curette. The insertion into the conjunctival sac of an non-irritating ointment every night at bed-time is a useful adjunct in the treatment by bandage or operation.

Blows on the Eye, amongst other lesions, are liable to cause Corneal Bullæ, the walls of which consist of Bowman's membrane and the epithelium. In some cases these bullæ contain blood, derived no doubt from the ruptured canal of Schlemm. Such bullæ may also form after burns with lime, etc.

Another condition caused by blows on the eye is *Hæmorrhagic Discoloration* of the true cornea, which presents a greenish or a reddish-brown colour in the cornea. Hæmorrhage in the anterior chamber is always present at first. At first, too, the discoloration occupies the whole cornea, and after a time begins to clear up from the margin towards the centre. The prognosis for vision is good, if the eye be otherwise sound, but the absorption of the colouring matter in the cornea is excessively slow, and as much as two or three years or more may elapse before the process is complete. Mr. Treacher Collins has ascertained that the peculiar discoloration in these cases is due to the presence of hæmatoidin, which he thinks enters the cornea from the hæmorrhage in the anterior chamber through Descemet's membrane by a process of diffusion. He did not find any red blood-corpuscles in the cornea.

Burns of the Cornea.—Burns of the cornea from lime are not uncommon. The lime acts as a caustic, and destroys the cornea more or less deeply, with resulting more or less intense permanent cicatricial opacity. The lime, moreover, enters into chemical combination with the corneal tissues in the form of the albuminate of lime, which causes further opacity.

Treatment.—As soon as possible after lime has entered the eye, it should be removed as thoroughly as possible by means of forceps and free washing out with water; or, better still, with saturated solution of sugar, which forms, with whatever loose lime may be present, an insoluble substance that may be readily removed.

The removal of such albuminate of lime as remains fastened deeply in the cornea is difficult to effect. When the irritation of the eye has subsided, a warm 2 per cent. solution of chloride of ammonium, which dissolves out the lime, may be applied, by means of an eye-bath, to the cornea. The bath is to be used several times a day for half an hour each time, and the strength of the solution may be gradually increased, according as the patient can bear it, up to 20 per cent.

Perforating Injuries of the Cornea.—In these cases the injury done is rarely to the cornea alone, and at the first inspection the attention of the surgeon is occupied less with the state of the cornea than with the question as to whether, and to what extent, deeper parts of the eye (iris, lens, vitreous humour, etc.) are involved. Another very important point, which has often to be decided, is whether or not the foreign body, which has perforated the cornea, is contained in the eye. But these matters belong to future chapters.

A perforating wound of the cornea, which does not involve any other part, is serious in proportion to its extent, and to the probability of its being infected. Every perforating corneal wound is followed by loss of the aqueous humour, which flows away through the opening, and by consequent collapse of the anterior chamber; but this in itself is not a serious event. Short wounds close almost at once (and through them indeed very little of the aqueous humour may flow off), the aqueous humour is rapidly restored, and no harm is done to the eye beyond a slight opacity, which, if in the pupillary area, may cause some defect of vision; or, should the wound be situated more peripherally, and should the iris have lain against the cornea for a while, an anterior synechia may form.

Long wounds, which may even occupy the cornea in its entire diameter without directly involving any other organ of the eye, are almost certain to be complicated by prolapse of the iris between the lips of the wound; and, when healing takes place the prolapsed portion becomes permanently incarcerated in the cicatrix. At the least, this incarceration causes irregularity in the curvature of the cornea, and consequent irregular astigmatism. But it may be the starting-point of a staphyloma of the cornea, it may become the cause of glaucomatous intraocular tension, or, if at any time a slight trauma with loss of substance of its surface should occur, it may take on septic inflammation, which may spread rapidly to the deeper uveal structures, leading to panophthalmitis and loss of the eye.

Treatment.—In small uncomplicated perforating wounds, without prolapse of iris, the aqueous humour being still wanting, atropine should be freely used if the wound be towards the centre of the cornea, or eserine if it lie toward the periphery, with the object of preventing adhesions of the iris to the posterior aspect of the wound, and a bandage should be applied to the eye.

In recent injuries of this kind, in which there is a prolapse of the iris, the prolapsed portion, if not very large, may sometimes be reposed with a spatula or fine probe, aided by the action of atropine or eserine, according to the position of the wound. But in many instances this attempt will prove futile, while in those in which there is suspicion of septic infection, it is unwise to make it at all. In either circumstance the prolapsed portion of iris should be snipped off at its base. It is not enough to abscise a portion of the summit of the prolapse. The prolapsed iris must be seized with an iris-forceps, drawn forward so as to loosen any adhesions between it and the lips of the wound (or the adhesions may previously be separated by a probe passed round the edges of the wound), and cut off close to the cornea. This affords the best hope of the iris receding into the anterior chamber without any of it adhering in the cornea. In badly lacerated wounds it is sometimes desirable to transplant conjunctiva over them (p. 221) in order to promote the healing process and to consolidate the cicatrix.

In cases which are not recent, the adhesions between cornea and prolapsed iris will have become so firm, that it will not be possible to separate them by any means, and the prolapse must be left to become cicatrised over, attention being directed to keep the tension of the eye low by means of eserine, punctures made in the prolapse, and the transplantation of conjunctiva, so as to produce a firm and flat cicatrix.

OPACITIES OF THE CORNEA.

Nebula, Macula, Leucoma.—These terms are applied to opacities of varying degrees in the cornea, which are the result of some diseased process, or which are consequent upon an injury. The first term is used for very slight opacities, often discoverable only with oblique illumination. Macula indicates a more intense opacity, recognisable by daylight. Leucoma is a completely non-translucent and intensely white opacity, the result almost always of an ulcer, which has destroyed most of the true corneal tissue at the affected place; indeed, it is often the result of an ulcer which has eaten its way quite through the cornea. In these latter cases the iris may have become adherent in the corneal cicatrix, and then the term adherent leucoma is employed.

Very often eyes with an old-standing nebulous condition of the cornea are myopic. It is probable that this myopia is produced partly by the habitual close approximation of objects to the eye, owing to the diminished acuteness of vision from the opacity of the cornea.

Treatment.—Little or nothing can be done to reduce these opacities. In slight and fresh cases, massage with the yellow oxide of mercury ointment may render them less intense.

In case of a nebulous cornea, a stenopæic apparatus often improves the sight. This consists of a metal plate with a small central hole or slit, which is placed before the patient's eye in a spectacle-frame; and by this arrangement a large portion of the rays which pass through irregular parts of the cornea, and which merely confuse the sight, is cut off. Should the opacity be dense, and situated in the centre of the cornea, portion of the margin having remained clear, an iridectomy will in some instances improve the sight.

The Operation of Tattooing was first proposed by De Wecker, and is a valuable proceeding for improvement of the appearance of the eye in cases of leucoma. It is also an extremely useful method for improvement of the sight, where the nebula occupies only part of the pupillary area of the cornea. In these latter cases, much disturbance of sight is caused by the dispersion of the light which makes its way through the nebula; and when, by tattooing the scar, all light is prevented from getting through, brighter and distincter vision is enjoyed with the part of the cornea, opposite the pupil, which is absolutely clear.

In the case of a leucoma, either the whole surface of the leucoma may be tattooed, or only part of it—*e.g.*, its centre, in order to represent a pupil.

The material used is fine Indian ink rubbed into a very thin paste. The eye having been cocainised, the leucoma is spread over with this paste, and then covered with innumerable punctures by means of de Wecker's multiple tattooing-needle, or with an ordinary discission needle, each stab of which carries into the cicatricial tissue some of the black pigment. The coloration continues sufficiently intense for some months, but then often begins to get pale, owing, probably, to the pigment falling out of the punctures. A method of tattooing, by which the pigmentation lasts longer, is performed with de Wecker's single grooved needle. The pigment is placed in the groove of the instrument, which is then passed into the leucoma, a long canal being made in a plane parallel to its surface. On withdrawal of the needle the pigment remains behind. A large number of such canals must be made in close proximity to each other, until the desired intensity of colour is obtained. Some operators remove the corneal epithelium over the part to be tattooed, in order to facilitate the entrance of the colouring matter into the true cornea.

In tattooing the cornea, the eye must not be fixed with a toothed forceps, or the conjunctiva may be tattooed. A forceps armed with rubber is made, or the eye can be fixed by the surgeon with his fingers, which at the same time take the place of a speculum (see p. 265).

* In cases where the whole cornea is leucomatous, and, consequently, where no restoration of sight can be obtained by means of an artificial pupil, *Transplantation of a Portion of Clear Cornea* from a rabbit's eye, or from a freshly enucleated human eye, has been repeatedly performed by ophthalmologists in various parts of the world. Very many of these operations have been perfectly successful in a surgical sense—*i.e.*, in so far as the healing-in of the transplanted flap was concerned; but, with a few exceptions, they all ended in disappointment, in consequence of the flap not retaining its transparency. In the course of a week or two the transplanted portion invariably became as opaque as the leucoma had been before. The mode of proceeding consisted in removing a portion of the leucoma with a trephine, and in then cutting a disc with the same instrument out of the clear cornea to be utilised, and inserting it into the opening in the leucoma.

Various theories were put forward to account for the occurrence of the opacity in the transplanted flap, but into these it is unnecessary to enter here. Von Hippel came to the conclusion that the onset of the opacity in the flap was due to entrance of the aqueous humour into the substance of the cornea, owing to the solution of continuity in its posterior epithelium; for it has been shown that, unless this epithelial layer be intact, the transparency of the cornea cannot be maintained. Von Hippel, acting on this theory, applied a trephine to the leucoma as deep only as the posterior elastic lamina, and then dissected off the superficial layers contained within the ring, leaving the posterior elastic lamina and posterior epithelium. With the same trephine he then excised a disc of its entire thickness from a rabbit's cornea, and applied it to the wound. Iodoform was dusted over this, and a bandage applied. Healing took place readily, and twenty months afterwards the flap continued transparent, and vision = $\frac{20}{200}$. Von Hippel has had some other successful cases, but the cases to which the proceeding is applicable are not of frequent occurrence.

Arcus Senilis.—This is a change which is developed in the cornea without previous inflammation. It presents the appearance of a greyish line all around and a little inside the margin of the cornea, most marked above and below, and never advancing farther towards its centre. It is more common in elderly people, but is sometimes seen in youth, and even in childhood. No functional changes are caused by it, nor does it interfere with the healing of a wound which may be made in that part of the cornea. Arcus senilis, as Mr. Parsons' investigations have shown, is caused by a peculiar fatty degeneration of the corneal cells and fibrillæ.

CHAPTER VIII

DISEASES OF THE EYELIDS.

ERYTHEMA, erysipelas, phlegmonous inflammation, and abscess are all liable to attack the eyelids, but require no special observations in this work. It should merely be stated that erysipelas of the eyelids may extend to the connective tissue of the orbit, and ultimately give rise to atrophy of the optic nerve.

Eczema.—This is very often seen on the skin of the eyelids, most frequently in connection either with general eczema of the face or with phlyctenular ophthalmia. The lacrimation in phlyctenular ophthalmia increases the eczema, which then, by causing contraction of the skin of the lower lid, often produces eversion of the inferior punctum lacrimale, and this, in turn, causes increased lacrimation.

Atropine infiltration of the eyelid, from use of atropine eye drops in some persons, is frequently accompanied by a moist form of eczema of the lids and face.

Treatment.—Should the use of atropine be the cause it is necessary to discontinue it, and to substitute solution of extract of belladonna as eye drops (gr. x and ℥j). As an application to the affected skin the following ointment is useful:—Oil of Cade, ♏ iv, Zinci oxidi, gr. v, Adipis lanæ hyd. vaselin alb., aa. ʒij.

Marginal Blepharitis (*βλέφαρον, eyelid*), or, **Ophthalmia Tarsi**, is nothing else than eczema of the margin of the eyelid. It is found either as **Blepharitis Ulcerosa** (Eczema Pustulosa), or as **Blepharitis Squamosa** (Eczema

Squamosa). In blepharitis ulcerosa, small pustules form at the roots of the eyelashes, and these, having lost their covering, become ulcers, which scab over. The whole margin of the lid may then be covered with one large scab, in which the eyelashes are matted, and under which the lid will be found swollen, red, and moist, with many minute ulcers and pustules, the latter due to suppuration of the hair follicles and sebaceous glands belonging to them. Cicatrices resulting from this suppuration are also present, and there the hair follicles are destroyed, and the cilia do not grow again. Many eyelashes come away with the scab, and others are found loose and ready to fall out.

The disease is chronic, and is most commonly seen in strumous children. It is frequently accompanied by phlyctenular ophthalmia, or by simple conjunctivitis, which may have been its cause, or which promotes it by keeping the margin of the lid constantly wet.

If neglected, ulcerous blepharitis, by reason of the scars it produces, is liable to give rise not only to loss of eyelashes, but to irregular growth (trichiasis) of those which remain. After a time the continued congestion and inflammatory swelling of the lid margin leads to its hypertrophy. This change, which is called tylosis, is seen chiefly in the upper lid. The margin of the lower lid is liable to become everted, owing to cicatricial contraction. Involved in this eversion is the lower punctum lacrimale, and consequently lacrimation ensues, with resulting eczema of this skin of the eyelid, which in turn promotes the ectropion, while the exposure of the conjunctiva of the lower lid increases the already existing conjunctivitis.

The Treatment of Ulcerous Blepharitis consists, in the first place, in the careful removal of the scabs without causing any bleeding of the delicate surface underneath. Such bleeding indicates that newly formed epithelium has been torn away, and it is important, therefore, to soften the scabs by soaking the eyelid with olive oil, or with a warm saturated solution of bicarbonate of soda, before removing them. Any pustules found under the scab should be punctured, and all loose eyelashes, which act as foreign bodies, taken away, and the ulcers should be carefully touched twice a week with a fine point of solid mitigated lapis. The surface should then be well dried by pressure, not by rubbing, with cotton wool, and the following ointment rubbed in with the tip of the finger—Hydrarg. præcip. alb. gr. vj, Zinci oxidi gr. viii, Liq. plumbi subacid ♏ vj, Adipis benzoat. ad. ʒiv. This ointment is to be continued by the patient, night and morning, after the lids have been washed, and all scabs and loose eyelashes removed from them, and well dried, until healing is thoroughly established. In many mild cases a boric acid ointment (gr. v ad ʒj of vaselin or of lanolin) will be found efficacious instead of the above. A creolin ointment suits many cases, if it does not irritate—viz., Creolin, 1 to 5 min.; Aq., ʒij; Lanolin, ʒvj.

Or, again, after the scabs and loose eyelashes have been removed as above, the margins of the eyelids may be freely bathed with a wash of ten to twenty minims of creolin to eight ounces of water, and after this the creolin ointment may be applied. A first principle of treatment in all these cases is that it be non-irritating.

All complications with conjunctival affections or lacrimal obstruction must be attended to, and the patient's general system carefully improved.

Squamous Blepharitis comes on after the ulcerous form has passed away; or it is found as a primary affection, especially in chlorotic women. The margin of the lid is somewhat swollen and red, and covered with loose epidermic scales. It is an extremely chronic affection, but, although disfiguring, it has no dangerous sequelæ.

The Treatment of Squamous Blepharitis. Boric acid ointment (gr. xxx ad ℥j).

Chlorosis, if present, is to have suitable remedies.

Phtheiriasis (*φθείρ, a louse*) **Ciliorum.**—The pediculus pubis occurs on the eyelashes. It gives rise to excessive itching and burning sensations, and the consequent rubbing produces excoriations of the margin of the lid. The lice occupy chiefly the roots of the eyelashes, to which they cling tenaciously, while the shafts of the cilia are covered with their brown egg-capsules, and this gives to the cilia the peculiar appearance of being covered with dark brown powder, which enables the diagnosis to be easily made. The fully developed parasites, as well as the eggs, may be more readily seen by aid of a strong convex glass.

Treatment.—With a cilium forceps the pediculi may be removed, as well as some of the eggs from the cilia. This proceeding repeated daily, along with the application of mercurial ointment, or of a weak red precipitate ointment, to the margin of the eyelids morning and evening, will soon effect a cure.

Hordeolum (*hordeum,* a grain of barley), or **Stye,** is a circumscribed purulent inflammation situated at the follicle of an eyelash. It commences as a hard swelling, with more or less tumefaction and œdema of the general surface of the lid, and often with some chemosis, especially if it be situated at the outer canthus. In its early stages there is much pain associated with it. It gradually suppurates, and may then be punctured or allowed to open of itself.

Styes frequently come in rapid succession, and then, probably, a constitutional disturbance exists as the cause. In the earliest stage cold applications may be successful in putting back a stye, but, later on, warm stupes will hasten the suppuration and relieve the pain. Habitual constipation is a common source of hordeolum, and should be met by the use of mild laxatives. Sulphide of calcium, $\frac{1}{10}$ gr. every hour, or $\frac{1}{2}$ gr. twice a day, for an adult, has been recommended as a specific in these cases, and treatment with nuclein may be found useful.

Chalazion (*χάλαζα, hail*), **Meibomian Cyst,** or **Tarsal Cyst,** is probably a granuloma in connection with a Meibomian gland, and not a mere retention cyst. Micro-organisms have been found by some observers in these tumours, but what relation exists between them and the tumours is a matter upon which opinions differ. Chalazion has its origin in a slight chronic inflammatory process in the connective tissue surrounding the gland, which usually passes off without having attracted the attention of the patient, but occasionally, when the cyst has developed, acute inflammation with formation of pus comes on. The tumours vary in size from that of a hemp-seed to that of a hazel-nut, causing a marked and very hard swelling in the lid without any redness of the latter. They occasionally open spontaneously on the conjunctival surface, giving exit to contents which are usually viscid or grumous, and sometimes purulent.

Treatment.—No application can bring about absorption of these tumours. The lid should be everted, the tumour opened by an incision from the conjunctival surface, and its contents thoroughly evacuated by aid of a small curette. Difficulty is sometimes experienced in finding the point in the conjunctiva corresponding to the tumour, but it is usually indicated by a dusky or greyish discoloration. Immediately after the evacuation, bleeding into the sac often takes place, and causes the tumour to remain for a day or two as large as before—a fact of which the patient should be warned. The operation may occasionally require to be repeated. The interior of the sac should not be touched with nitrate of silver; and the incision and evacuation should not be made through the skin, unless in rare instances when the capsule is exceptionally thick, as more or less disfigurement from the scar results.

More than one chalazion is often present at a time, and some people become liable to them periodically during a number of years, especially those who suffer from acne of the face.

* **Milium** (*milium*, a millet seed) presents the appearance of a perfectly white tumour, not much larger than the head of a pin, in the skin of the eyelid. It is a retention tumour of a sebaceous gland, and can readily be removed by puncture and evacuation.

* **Molluscum,** or **Molluscum Contagiosum.**—This is a white tumour in the skin of the eyelid, which may attain the size of a pea. At its summit is a depression, which leads to an opening into the tumour, through which the contents can be pressed out. It is probably a diseased condition of a sebaceous gland, and contains altered epithelial cells, and peculiar bodies, termed molluscum corpuscles, which are of a fatty nature. Many such tumours may form in the lids at the same time. It is held by some observers that this affection is contagious, although in what way is not clear, inasmuch as experimental rubbing of the contents of a molluscum into the skin has not given rise to the tumours.

Treatment.—Each separate tumour must be evacuated by simple pressure, or after it has been opened up with a knife or scissors.

Teleangiectic Tumours, or **Nævi,** of the eyelids occur congenitally.

Treatment.—Small tumours of this kind may be destroyed by touching with nitrate of silver or hydrochloric acid, or by performing vaccination on them in the infant, instead of on the arm. Larger tumours may be ligatured or treated with the galvano-cautery, or ethylate of soda, and electrolysis is a very effectual method in many cases.

* **Xanthelasma** (ξανθός, *yellow;* ἔλασμα, *a layer*) is the term applied to yellowish plaques raised slightly over the surface of the skin of the eyelid, with very defined margins,

Women are more liable to it than men. The patches are generally bilateral and symmetrical, and are most frequently situated in the neighbourhood of the inner canthus. The shape of these plaques is extremely irregular, and they may attain the size of a shilling or larger. The appearance is caused, as Parsons has shown, by changes in the middle layers of the corium, consisting of aggregations of large epithelioid cells, with development of connective tissue, and of yellowish brown pigment in and about the cells, with fatty degeneration of the connective tissue.

Treatment can only consist in removal by careful dissection, and this is hardly to be recommended except under exceptional circumstances.

***Palpebral Chromidrosis** (*χρῶμα, colour ; ἵδρωσις, sweating*).—The phenomenon of an exudation of pigment upon the eyelids, of which a good many cases are recorded, has given rise to much discussion. The opinion held by many is that these cases are always the result either of deception in hysterical individuals, or of accidental circumstances, such as the exposure of a patient with seborrhœa palpebrarum to an atmosphere loaded with coal-dust or pigmentary matter, in some manufacturing district. Of the fact that the appearance has occurred under both of these conditions there can be no doubt. There would seem also to be evidence that some genuine cases of colour-sweating on the eyelids have been observed ; but they must be extremely rare. The discoloration is blue or black, and occurs in the form of fine powder upon the skin of one or both eyelids of both eyes. It can be wiped off, and is said to begin to reappear after a short interval. The subjects of it have been chiefly young girls, but it has also been seen in women of advanced years, and even in middle-aged men.

The Treatment in a genuine case may consist in the application of a lotion of liq. plumbi and glycerine ; and, internally, the general system, particularly in respect of any uterine derangement.

Herpes Zoster Ophthalmicus is a herpetic eruption of the skin in the region supplied by the ophthalmic division of the fifth nerve of one side.

Occasionally in the same case the second division of the fifth nerve may be affected, and, yet more rarely, the third division as well. One or two cases, too, have been published in which the zoster affected each side of the face.

But by far the most common case is the simple herpes zoster ophthalmicus, in which only the region supplied by the ophthalmic division of the fifth nerve is affected; and of this region it is usually that portion alone which pertains to the supra-orbital and infra-trochlear branches that is involved, as is represented in Fig. 124. The number of vesicles varies much; there may be but one, or there may be several, or they may be so numerous as to become confluent.

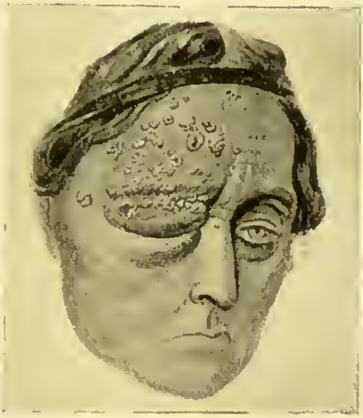


FIG. 124.

The appearance of the eruption is often preceded by a feeling of general discomfort, gastric disturbance, and high temperature. Yet more commonly is the eruption preceded by supra-orbital neuralgia, which is often of intense severity. This pain usually continues, but may cease, after the eruption comes out, and sometimes it persists even for months after the eruption disappears. Photophobia, due to the irritation of the fifth nerve, is not uncommon at the commencement of the ances are often mistaken for erysipelas, but the strict limitation of the eruption by the middle line of the forehead is of itself sufficient to indicate the diagnosis. The upper lid is somewhat œdematous and red, and droops over the eye, and this is much more marked when the skin of the eyelid itself is the seat of vesicles.

The contents of the vesicles soon become purulent and hæmorrhage may form in them. They then gradually dry up, and form crusts, which conceal more or less deep ulcers, and as these penetrate to the corium they leave permanent scars behind, which at first are red, and later become of a glistening white. The entire eruptive process lasts about three weeks; and, when it is completed, the sensibility of the affected skin remains dull for a considerable time. Herpes zoster ophthalmicus is more common in advanced life than in youth, but it may appear at any age, even as early as the sixth month after birth.

The disease is not associated with danger to the eye, unless keratitis come on, or, what is much more rare, unless iritis, cyclitis, or chorioiditis appear. Hutchinson laid down the rule that the cornea does not become affected, unless the eruption appear on the region (the side of the nose) supplied by the naso-ciliary nerve—this being the nerve which gives the long root to the ciliary ganglion, as well as the long ciliary nerves—but it is a rule to which there are many exceptions. The conjunctiva is almost always slightly chemotic and injected, or there may be true conjunctivitis; but vesicles are not often seen on it.

There is considerable variety in the forms of keratitis liable to occur in herpes zoster ophthalmicus—viz., herpetic vesicles, phlyctenulæ, bullæ (any of which may go on to ulceration), superficial opacity without loss of substance, and parenchymatous opacity, either diffuse or punctate. The superficial opacities without loss of substance may disappear altogether, or remains as a slight nebula; while ulceration leaves, at the least, some opacity; or, if it become septic, may seriously endanger the eye. Anæsthesia, more or less well marked, attends the corneal affections, and remains for a long time after they recover.

Iritis is very uncommon in herpes zoster ophthalmicus, and is usually of a mild type, and irido-cyclitis and chorioiditis are still more uncommon. They seldom occur unless keratitis be also present, and, like the keratitis, for the most part only when the cilio-nasal nerve is implicated.

Herpes zoster ophthalmicus is due to an inflammatory process in the Gasserian ganglion, as Head and Campbell have shown, and in the opinion of these authors the skin eruption is caused by intense irritation of the ganglion cells. The lesion in the Gasserian ganglion is similar to that found in the posterior root ganglion in zoster of the trunk and limbs. Head and Campbell believe the affection to be an acute specific disease—a view suggested by the facts that it occurs in the course of recognised infective diseases, that it occurs endemically and epidemically, and that it rarely occurs a second time. It is probable that the affection may also have a toxic origin, as when arsenic has been taken for a long time, and in carbonic oxide poisoning.

Treatment.—It is doubtful whether treatment has any influence in curing or in controlling the severity of an attack of herpes zoster ophthalmicus. Quinine in full doses should be given, and a 1 per cent. cocaine ointment made with equal parts of vaseline and lanolin should be smeared lightly over the affected part. Complications in the cornea or uveal tract are to be dealt with on the principles laid down in the chapters on diseases of those organs. The patient, unless the attack be a very mild one, should be confined to bed.

* **Syphilitic Affections of the Eyelids.**—*Primary*

of the upper or lower lid, or at the inner or outer canthus, or may occupy the conjunctival surface of the eyelid. The first appearance is generally a small red swelling which the patient calls a "pimple," and which ulcerates and becomes characteristically indurated about its base. The margin of the ulcer is clean-cut, and its floor somewhat excavated, and covered with a scanty greyish secretion. Or, without any ulceration, the lid is swollen, greatly indurated, purple, and shiny; and in these cases the diagnosis may be somewhat difficult. The præ-auricular and sub-maxillary glands are almost always swollen; and this is a valuable, although not altogether positive, diagnostic sign, as it is seen also in tubercular diseases of the conjunctiva. The occurrence of the sore is followed by the usual constitutional symptoms of syphilis. Very rarely is there any permanent damage done to the eyelid.

The most common modes of infection are by a kiss from a syphilitic mouth, or by a dirty finger.

In view of the rarity of this affection, as also of interstitial keratitis in acquired syphilis, quite a number of cases have been recorded (and an instance has come under the notice of one of the authors), in which interstitial keratitis followed in the eye of which the eyelid had previously been the seat of a primary syphilitic sore.

Treatment.—Locally, iodoform ointment, dusting with finely powdered iodide of mercury, or the black wash may be used; while the usual general mercurial treatment is employed.

Secondary Syphilis gives rise to ulcers on the margins of the lids, to loss of the eyelashes (madarosis), and to the secondary skin affections which attend it in other parts of the body.

In *Tertiary Syphilis* a gummatous infiltration of the tarsus—so-called Syphilitic Tarsitis—may occur, but it is a rare affection. One or both eyelids, in one or both eyes, may be attacked. Without pain the lid becomes slowly and gradually hypertrophied, and the integument tightly stretched and hyperæmic. On palpation, which gives no pain, the tarsus can be felt, enlarged and of cartilaginous density. The palpebral conjunctiva is somewhat swollen, but through it the yellowish-white colour of the gummatous infiltration can be seen, if it be possible to evert the lid. Ptosis results, and the lid may be so hard and stiff as to render eversion impossible. The eyelashes fall out, and the pre-auricular gland is swollen. Although, as stated, the process is remarkable for its freedom from pain, yet severe pain may be experienced, should a rapid increase in the gummatous infiltration take place. Under treatment—which consists of iodide of potash and mercury—the infiltration disappears, and leaves a normal eyelid behind, or the tarsus may be somewhat atrophied as a result.

* **Vaccine Vesicles on the Eyelids** are produced by accidental inoculation at the intermarginal part of the lid; or on the outer surface of the lid, if the skin be abraded by the finger-nail or otherwise. Sometimes the vesicle develops into a large ulcer with yellowish floor and hard and elevated margin. There is much pain, much swelling of the eyelid, and chemosis.

Although distressing for a week or so while it lasts, the affection is not a dangerous one, further than that a cicatrix in the skin is left behind, and the eyelashes at the affected part are lost.

Treatment.—A warm chlorate of potash lotion (gr. v ad ℥j) is the best application.

Rodent Ulcer (Jacob's Ulcer).—This disease commences as a small pimple or wart on the skin near the inner canthus, or over the lacrimal bone, as a rule; but it may also originate in any other part of the face. The scab or covering of the wart is easily removed, and underneath is found a shallow ulcer with a well-defined indurated margin, the skin surrounding the diseased place being healthy. The progress of the disease is extremely slow, extending over a great number of years, and in the early stages the ulcer may even seem to heal for a time, but always breaks out again. In mild cases the ulceration may remain superficial; but more usually it strikes deep, in the course of time eating away every tissue, even the bones of the face and the eyeball. The latter is often spared until after the orbital bones have gone.

The disease is an epithelial cancer of a non-malignant or purely local kind. There is no tendency to infiltration of the lymphatics. It is rarely seen in persons under forty years of age.

Treatment.—Extirpation of the diseased part with the knife, followed by the application of chloride of zinc, or of the actual cautery, used formerly to be employed; and Bergeon's treatment, with the internal administration of chlorate of potash, and its local application as a lotion, was also used with benefit for the time. But all other measures have here given way to the X Ray treatment, which now enables brilliant cures to be effected in the majority of these terrible cases. Dr. W. S. Haughton, who is in charge of the X Ray department of the Victoria Hospital, has given us the following description of the method which he finds to be the most successful in the treatment of rodent ulcer:—When the ulcer is large, lumpy, or prominent, it is advisable to remove as much as possible of its floor and margin by excision or cautery, so as to expose its growing base directly to the X Rays. The affected part is given two minutes' exposure to the X Rays every second day, until definite signs of X Ray reaction appear. The ulcer is exposed, at a distance of not less than six inches, through an accurately shaped window in a mask of lead foil. A layer of cotton-wool or other non-conducting material is placed between the patient's skin and the lead foil. For superficial ulcers a soft X Ray tube gives the best results, when deep tissues are affected a hard tube is preferable. From 10 to 20 sittings according to the extent and depth of the ulcer, are usually necessary to effect a cure. Early cases are of course the most favourable for treatment, but in far advanced cases—even when the eyeball was gone, and the bones of the orbit extensively destroyed, with visible pulsations of the brain through the roof of the orbit—the growth of the disease has been arrested, and all pain and hæmorrhage have been stopped. In rodent ulcers of small extent radium is capable of effecting good cures. Two or three 5 mg. tubes of first quality radium are applied to the ulcerated surface for about half an hour, and at a different part of it at each sitting, which occurs at intervals of ten days to three weeks, until gradually the whole surface is brought to heal. The cicatrix left is remarkably soft and skin-like.

* The condition known as **Solid Œdema**, or **Elephantiasis Lymphangioides of the Eyelids**, is well represented in the accompanying picture (Fig. 125[1]) of a case under the care of Sir A. Critchett. It is a chronic tumefaction of the eyelids, most marked in the lower lids. The skin covering the swelling is smooth and pale, and suggests to the eye the skin of an œdematous lid; but on palpation the swelling is found to be much more resistant than simple œdema. There is, almost invariably, a history of recurring attacks of facial erysipelas. These give rise to a permanent alteration of the lymph channels, and, each attack leaving its trace, an ever-increasing hypertrophy of the tissues of the eyelids takes place.

Treatment.—Operative measures have been adopted in many instances with satisfactory results, both cosmetically and as regards the functions of the eyelids; but, unfortunately, in those cases which have remained under observation sufficiently long, the former condition gradually returned, as in Sir A. Critchett's case, in the picture of which the cicatrices of the operations can be seen. Multiple punctures, collodion, pressure, etc., and many internal remedies have been tried in vain.

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[1] *Trans. Ophth. Soc. U.K.*, vol. xix.

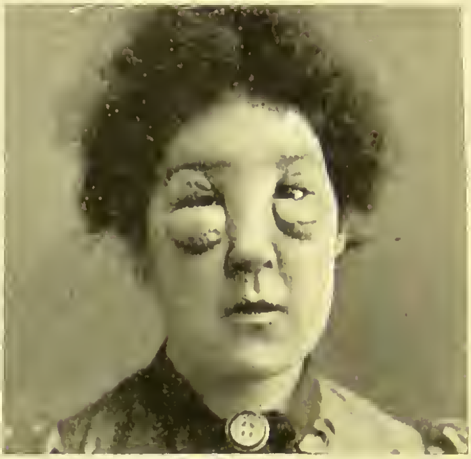

FIG. 125.

* **Plexiform Neuroma**, or **Neuro-fibroma** is a rare disease of the eyelids. It is seen as a congenital growth which slowly increases in size. To the touch the tumour in general is soft, but contains many hard strings and knobs. Pressure on it is painful in some cases. It may attain great size, and may extend to the supra-orbital, temporal, and malar regions, giving rise to much disfigurement. Operation is indicated only if the tumour be markedly progressive, as a satisfactory result is not very attainable, and gangrene has followed in some cases, while in others, where the growth had to be followed deeply, severe hæmmorrhage has occurred. In some instances the tumour

has invaded the orbit, and even the cavity of the skull, after absorption of the orbital roof.

* **Lymphoma** or **Lymphadenoma** of the eyelids is usually seen as a bilateral and symmetrical disease, but it does occur on one side only in rare instances. It is frequently associated with leucæmia, or pseudoleucæmia, or it may be found in apparently healthy individuals. It often invades the orbit, and its growth is exceedingly slow and quite painless.

* **Epithelioma, Sarcoma,** and **Lupus** are all seen in the eyelids, but require no special description here.

* **Gangrene of the Eyelid** is a rare condition. It may occur as a consequence of an infected wound of the lid, or from some general infection of the system, even in influenza, and has been seen as a result of excessive use of iced compresses.

Clonic Cramp of the Orbicularis Muscle, or of a portion of it, is often seen, and is popularly known by the name of "life" in the eyelid. It is frequently due to overuse of the eyes for near work, especially by artificial light, or if there be defective amplitude of accommodation.

Treatment should consist in the regulation of the use of the eyes for near work, and the correction by glasses of any defect in the accommodation.

Blepharospasm, or **Tonic Cramp of the Orbicularis Muscle,** is commonly the result of irritation of the ophthalmic division of the fifth nerve by reflex action, as in phlyctenular ophthalmia and some other corneal and conjunctival affections; or from foreign bodies on the conjunctiva or cornea, etc.; or it may continue for some time after the relief of any such irritation. It occurs, also, independently of such causes, and is then difficult to account for, unless as a hysterical symptom. Yet even in these obscure cases the spasm is probably often a reflex from the fifth nerve (*i.e.*, teeth, or nose), and it will be found that pressure upon the supraorbital nerve at the supraorbital notch may arrest the spasm; or, if not there, then pressure on the infraorbital, temporal, malar, or inferior alveolar branch may have the desired effect.

Treatment.—If the cause of the reflex cannot be ascertained, or if it have passed away, and if the cramp be still very distressing, stretching or resection of the branches of the fifth nerve, from which the reflex proceeds, may be tried. The operation of spino-facial anastomosis has been successfully employed in some obstinate cases.

Ptosis (πτῶσις, *a fall*), or **Blepharoptosis**, is an inability to raise the upper lid, which then hangs down over the eyeball. It is either congenital or acquired; and in the latter case is most usually the result of paralysis of the branch of the third nerve supplying the levator.

Persons affected with ptosis involuntarily endeavour to raise the eyelid by an over-action of the frontalis muscle. The drooping lid and elevated eyebrow give a peculiar and characteristic appearance.

The Causes of Paralytic Ptosis are similar to those of paralysis of other branches of the third pair, more especially exposure to cold draughts of air while the body is heated, and syphilis or rheumatism affecting the branch to the levator palpebræ in its course. It may also be due to cerebral disease (see chap. xviii.). The branch to the levator may be paralysed alone, or in conjunction with other third-nerve branches, especially to the superior rectus, and the loss of power may be partial or complete.

Some cases of bilateral ptosis in elderly people due to primary atrophy of the levator palpebræ muscles have been recorded. The eyelids were elongated and thinned, so that the eyeball showed plainly through them. The loss of power had in each case been very slowly increasing for many years.

The Treatment of a recent case of ordinary paralytic ptosis depends upon its cause. If this be syphilis, then a course of mercurial inunctions or of iodide of potassium; if rheumatism, salicylate of soda or iodide of potassium—with, in either case, protection of the eye and side of the head by means of a warm bandage. Cases in which these remedies have failed, and which have become chronic, often demand operative treatment. Attempts have been made, with success in some cases, to obviate the inconvenience of ptosis by giving support to the lid by wire splints worn like an eyeglass or attached to the upper edge of spectacle-frames.

Ptosis due to a cerebral lesion rarely comes within the scope of treatment.[1]

*Operative treatment is indicated in cases of paralytic ptosis—where other measures have produced no result—in ptosis adiposa, and in congenital cases. A very common proceeding consists in the excision of a sufficiently large oval piece of integument, its long axis lying in the length of the lid, with the subcutaneous connective tissue and fat, and, in paralytic cases, a small portion of the orbicular muscle. The fold of integument to be abscised is seized by two pairs of forceps—one of them held by an assistant—at the inner and outer ends of the lid, and by this means the necessary size of the fold is estimated. The abscision of the fold is performed with a pair of scissors, the margin of the wound lying close to the points of the forceps. The subcutaneous tissue, etc., is then removed, and the edges of the wound drawn together by a few points of suture.

* *Mule's Operation.*—This operation is one of the many designed to enable the patient to derive more benefit from the effort of his frontalis muscle, which he is constantly making with so little result, by transferring its action more directly to the eyelid. A Knapp's clamp is applied to the lid to be operated on. The edge of the tarsus is then grooved one-third of an inch in length and deeply enough to permit

of perfect and easy healing over the wire bend (Fig. 127, D); the grooving should be behind the bulbs of the lashes, to

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[1] The value of ptosis as a localising symptom in cerebral disease will be treated of in chap. xvii.

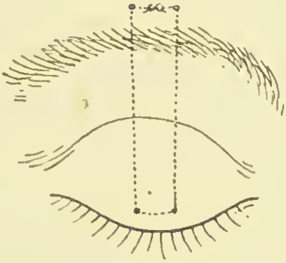

FIG. 126.

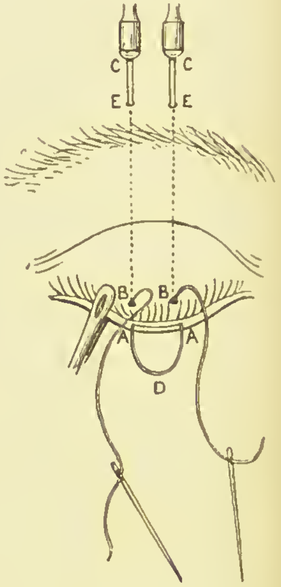

FIG. 127.

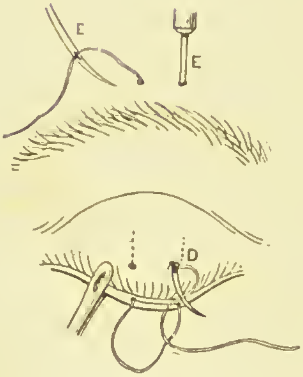

FIG. 128.

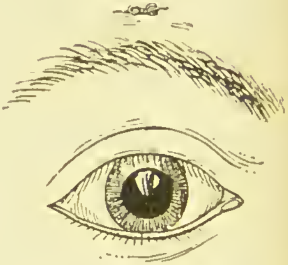

FIG. 129.

Fig. 126 shows intended track of wire.
Fig. 127.—Wire loop D, with needle ends passed upwards in thickness of tarsus, and turned out at B B, to be taken subcutaneously to E E by ptosis needles (C C) passed from above eyebrow.
Fig. 128 shows wire at E in eye of ptosis needle above eyebrow; D, point of needle threaded with wire projecting at middle of lid before being drawn up to E.
Fig. 129.—Completed except sinking wire knot permanently.

prevent their being directed abnormally inwards. After grooving, the Knapp's clamp may be removed, and the lid drawn tense with the lid-forceps. Next, at each end of the groove (Fig. 127, A A), one sewing needle with wire is passed upward half the width of the lid in the centre of the tarsus, so as to give a strong bite for the wire bend, then thrust forwards and outwards through the tarsus (at B B) and skin, the wire being drawn through the small incision made there. The ptosis needles (C C) are now pushed deeply from above the brow, a quarter of an inch apart, into the tiny apertures made for them by a thrust of the sclerotomy knife, then underneath the eyebrow downwards to the incision (B B) in the skin of the lid, through which the wire has already passed, and their points are also turned out there (Fig. 128, D). The wire is cut from the sewing-needles, threaded through the eyes in the points of the ptosis needles, withdrawn through the small apertures in the skin of the lid, and brought out above the brow at the points of entry of the ptosis needles (E). The wire bend is then drawn firmly into the grooved edge of the lid to allow of immediate healing, a little iodoform dusted on the groove and small incisions, the wire ends shortened, the apertures dressed with collodion, and iodoform, and a pad and bandage applied. After all swelling of the lid has passed, the permanent effect may be secured by tying the wire after careful adjustment of the lid, and sinking it into a small skin incision made for the purpose (Fig. 129). Harman uses fine gold chain which *is* more flexible than wire.

**Birnbacher's Operation.*—An incision, with its convexity upwards, is made in the skin corresponding to the upper edge of the tarsus. Three sutures with a needle at each end are passed through the upper border of the tarsus, so as to form three loops, one central and two lateral; the two needles of the central loops are passed vertically upwards under the skin, and are brought out quite close to one another in the eyebrow. The lateral loops are treated in the same way, but are made to diverge on each side from the central one, instead of being parallel. The ends of the threads are tied over a small roll of lint, and tightened until the edges of the lids just touch when the patient closes the eye. They may be left in from twenty to twenty-five days.

Congenital ptosis is generally present in both eyes. It is due in some cases to an imperfect development of the levator palpebræ, and in others to an abnormal insertion of this muscle, its tendon being attached to the tarsus too far back. Either Birnbacher's or Panas' operation may be employed, and Eversbusch has proposed the following proceeding more particularly for congenital ptosis:—

* *Eversbusch's Operation for Congenital Ptosis* (Figs. 130 and 131).—The object of the operation is to increase the power of the levator by advancing its insertion, or rather by doubling it down over the tarsus, to which it forms fresh adhesions. Knapp's lid-clamp is applied, the plate being passed well up into the fornix; and, before the ring is screwed down, the skin of the lid is drawn down, so that its prolongation just under the eyebrow may be forced into the instrument. The skin and the underlying orbicularis are now divided in the entire width of the lid, parallel to its free margin, and at a distance half-way between this margin and the eyebrow. The skin and the subjacent muscle are then separated up, both upwards and downwards, for 4 mm. in each direction, so that the insertion of the levator may be well exposed. A suture with a small curved needle at either end is then introduced, by means of one of these needles, horizontally into the tendon at its insertion, and near the centre of the latter, in such a way that about 2½ mm. of the tendon may be included in the suture. Each needle is now passed vertically downwards between the tarsus and orbicularis, and brought out at the free margin of the lid at a distance from each other of about 2½ mm. Two more such double sutures, one in the temporal, the other in the nasal, third of the tendon, are similarly applied. The margins of the hori-

zontal skin and muscle wound are now drawn together, and then the three sutures are closed tightly. It is desirable to slip glass beads over the ends of the sutures before tying them, to prevent cutting into the margin of the lid. Both eyes are bandaged, and the sutures left in for a week or more.

While the foregoing, and other, operations relieve the ptosis, they are liable to give rise to some unsightly cicatrices, and are sometimes not permanent in their effect. With a view to obviate these drawbacks, Carl Hess has devised the following operation.

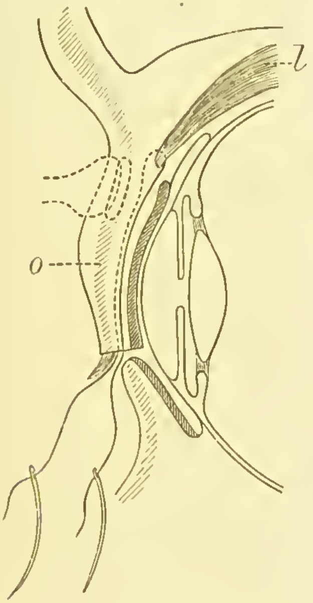

FIG. 130.

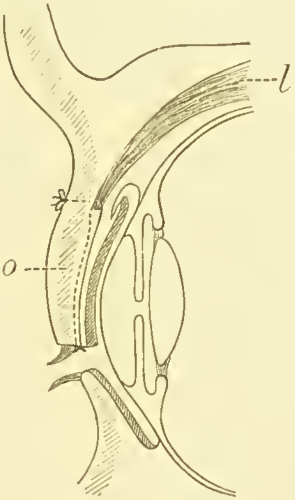

FIG. 131.

l, levator palpebræ ; *o*, orbicularis.

Hess' Operations.—The eyebrow having been shaved, an incision (*a a*, Fig. 132) is made in its whole length, and carried through the skin and subcutaneous tissue ; and, starting from this incision, the skin of the lid is separated with the scalpel from the underlying orbicular muscle nearly as far as the ciliary margin (dotted line in Fig. 132).

When the hæmorrhage has ceased, three silk sutures, each armed with two needles, are introduced, one at the centre and one towards either end of the eyelid, and about half-way between the eyebrow and lid margin (*b*, Fig. 132), or somewhat nearer the latter. The needles of each suture are inserted about 5 mm. apart, and, being passed from without inwards through the skin, they are brought out in the space made by the skin dissection. The needles are now passed deeply under the upper border of the incision in the eyebrow, and brought out a few millimetres above it (at points represented by three pairs of dots in Fig. 132). The two ends of each suture are tied over a small roll of lint or a bit of rubber drainage tube, and drawn tightly enough to relieve the ptosis by producing a fold in the skin flap. The wound in the eyebrow is united by some points of suture. The sutures are allowed to remain for eight or ten days. The permanent result depends on the union and cicatrisation of the extensive raw surfaces in their new position. The operation causes little or no disfigurement, as the artificial fold falls in about the same situation as that which is present in the normal eyelid, while the cicatrix in the eyebrow is concealed by the hairs when they have grown again. In Figs. 133 and 134 a section of the eyelid after tightening of the sutures is represented.

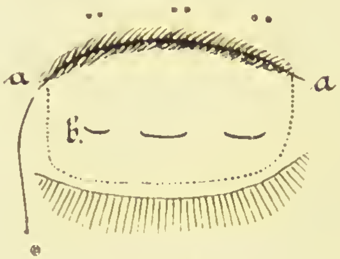

FIG. 132.

*A remarkable condition is *Congenital Ptosis, with Associated*

Movements of the Affected Eyelid, during the action of certain muscles. There are only about thirty cases of this on record. It is most commonly the left lid which is affected, and the paralysis may be congenital or acquired. Three conditions have been observed—viz., (1) elevation of the drooping lid when the eye is adducted, (2) when the eye is abducted, or (3) when the mouth is opened. A synchronous contraction of the pupil has been noticed in some cases, while in some the elevation of the lid occurs also with a lateral motion of the jaw, and with deglutition. Gower's explanation is that in these cases the levator is not wholly supplied by the third nerve, but partly also by nerve fibres which take their origin in the nucleus of the fifth pair, and which also supply the external pterygoid and digastric muscles. But this theory does not hold good in all cases, for Bull describes a case in which the lid was raised when the head was bent back, thus stretching the digastric, and he regards these as associated or reflex movements. In some instances the lid can be raised voluntarily on closing the other eye. Needless to say, no remedy can be applied for relief of this condition.

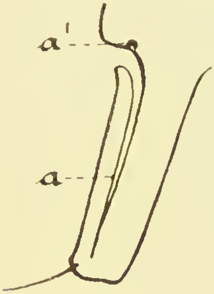

FIG. 133.

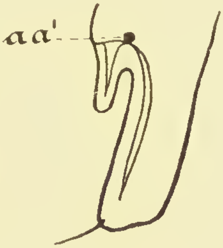

FIG. 134.

FIG. 133.—The needles are passed in at *a* through the skin of the lid, and brought out at *a'* through the skin and subcutaneous tissue above the eyebrow.

FIG. 134.—When the sutures are tightened *a* is closely approximated to *a'*.

The term ptosis is also given, although not very correctly, to cases in which increased weight of the lid causes it to droop, as in conjunctival affections, or where a tumour has formed in the eyelid, or where there is a hyper-development of the subcutaneous fat.

* **Lagophthalmos** (λαγώς, *a hare*, as it was supposed that this animal sleeps with its eyes open ; ὀφθαλμός), or inability to close the eyelids, is most commonly due to paralysis of the portio dura, and is then associated with the other symptoms of the latter affection. On an effort to close the lids being made, the eyeball is rotated upwards under the upper lid, owing to the associated action of the superior rectus ; and in sleep this upward rotation also occurs—a fact which explains, to a great extent, the immunity of the cornea from ulceration in many of these cases. Lagophthalmos may also be due to orbital tumours pushing the eyeball forwards, to exophthalmic goitre, to staphyloma, or to intraocular growths distending the walls of the eyeball—in all of which conditions the eyelids are often mechanically prevented from closing over the eyeball, or can be closed only by a strong effort of the will. The danger to the eye depends upon the tendency to ulceration of the cornea from its dryness, caused by exposure to the air, and from foreign substances not being removed from it by nictitation.

In cases of non-paralytic lagophthalmos, protection of the cornea by keeping the eyelids closed with a bandage, or by inserting a few epidermic sutures in the margins of the eyelids to draw them together, should be our first care. Tarsoraphy may be employed in those cases where circumstances indicate that it would be useful—*e.g.*, in some cases of exophthalmic goitre, or of staphylomatous eyeball.

In paralytic cases, the primary cause of the paralysis (syphilis, rheumatism, etc.) must be treated so long as there is a prospect of restoring power to the muscle. Locally, galvanism and hypodermic injections of strychnia may be employed. During cure the cornea should be protected as above. In incurable cases, the opening of the eyelids must be reduced considerably in size by an extensive tarsoraphy, or by the method proposed by Pflüger.

The Operation of Tarsoraphy consists in uniting the margins of the upper and lower lids in the neighbourhood of the external commissure, so as to reduce the size of the opening of the eyelids. The commissure should be caught between the finger and thumb, and the edges of the lids approximated, so as to enable the operator to form an estimate of the required extent of the operation. A horn spatula is then passed behind the commissure, and the necessary length of the margin of each lid, including the bulbs of the cilia, abscised with a sharp knife. The raw margins are then brought together with sutures.

Pflüger's Method consists in passing one, two, or even three double sutures subcutaneously around the eyelids, about 5 mm. from their margins. The ends are drawn together, so that the eye is concealed by the pouch thus formed, and tied. From time to time the sutures are tightened, until finally they cut through, and by this means a subcutaneous ring-cicatrix is produced. Should the first ring-cicatrix not sufficiently close the eyelids, the operation can be repeated even more than once again. The method is tedious and painful.

Symblepharon (*σύν, together; βλέφαρον, the eyelid*) is an adherence, partial or complete, of the eyelid to the eyeball. It is usually the result of burns of the conjunctiva by fire, acids, or lime. The shortening of the conjunctival sac, which is seen as the result of pemphigus or of granular ophthalmia, and which is described above under the heading of Xerophthalmos, is not properly termed symblepharon. If the symblepharon interfere seriously with the motions of the eyeball, or if it cause defect of vision by obscuring the cornea, it becomes desirable to relieve it by operation. Should it consist of a simple band stretching from lid to eyeball, it may be severed by ligature, and if the band be broad, two ligatures may be employed, one for either half. A symblepharon which occupies a considerable surface cannot be got rid of in this way; and for such cases a transplantation procedure like that of Teale may be employed, the great difficulty in dealing with these cases being the tendency there is to re-union of the surfaces, unless one or both of them be carpeted with epithelium.

* In *Teale's Operation*, if we suppose the case to be similar to that represented in Fig. 135, an incision is carried along the line of the margin of the cornea at *A*, through the whole thickness of the symblepharon, and the lid is dissected off from the eyeball as far as the fornix. Two conjunctival flaps are now formed, as at *B* and *C* in Fig. 136, and one of them (*B*) is turned to form a covering for the wounded surface of the inside of the eyelid, while the other (*C*) is used to cover the bulbar surface (Fig. 137), the flaps being held in their places by fine sutures. That part of the symblepharon which is left adherent to the cornea soon atrophies and disappears. No great tension of the flaps should exist as they lie in their new positions.

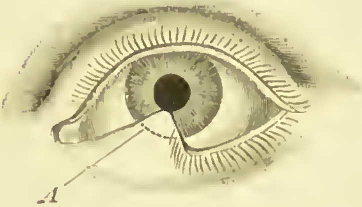

FIG. 135.

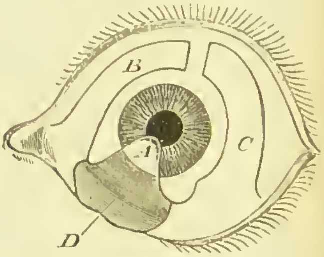

FIG. 136.[1]

Teale, again, has suggested the formation of a bridge-like conjunctival flap above the cornea, and the removing of it across the latter to cover the loss of substance situated below. After the sutures to keep the flap in its place have been introduced, the latter is separated at its bases.

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[1] Mr. Teale now makes his flaps, as in Fig. 136, wider than he originally did. He has been so kind as to alter this drawing with his own hand for this work.

A simple plan, which would be applicable to such a case as that depicted in Fig. 135, where the adhesion is not very extensive, and perhaps even to some more extensive ones, consists in dissecting the conjunctival process off the cornea, and then turning it down on the raw inner surface of the under lid, and fastening it there with a suture or two. We have done this with complete satisfaction.

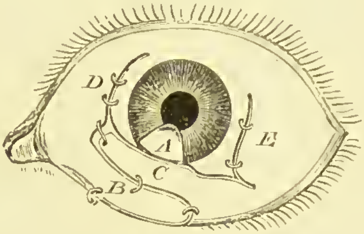

FIG. 137.

* *Harlan's Operation.*—This is specially applicable to extensive symblepharon of the lower lid, and differs from the foregoing operations in that it provides a covering of skin, and not of mucous membrane, for the raw surface of the underlid. Operations on the same principle have been proposed by Snellen and by Kuhnt. An incision (A B, Fig. 138) through the whole thickness of the eyelid, and corresponding in length to the latter, is made along the lower margin of the orbit. Below this a skin flap (C D) is then formed. The flap is dissected up, and the incisions are carried a little more deeply as A B is approached, to enable the flap to turn the more readily. The flap is then turned up as on a hinge, slipped through the buttonhole, and sutured securely to the inner surface of the under-lid. After a time the skin surface turned towards the eyeball becomes considerably modified, so as to be somewhat like mucous membrane. The bare space left by the removal of the strip of skin

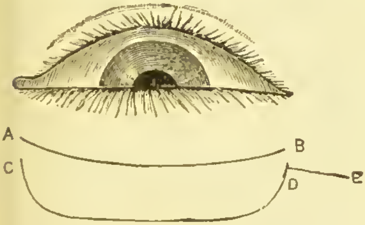

FIG. 138.

is covered without strain by making a small horizontal incision (D E) at its outer extremity, and forming a sliding flap.

Transplantation Operations.—The transplantation of mucous membrane from the lips or cheek has been used in extensive symblepharon, but the drawback to mucous membrane flaps, where two opposing surfaces have to be covered is that when the superficial epithelium of the mucous membrane is thrown off there is danger of the surfaces uniting. Thiersch and other skin flaps are preferable (see chap. xix.).

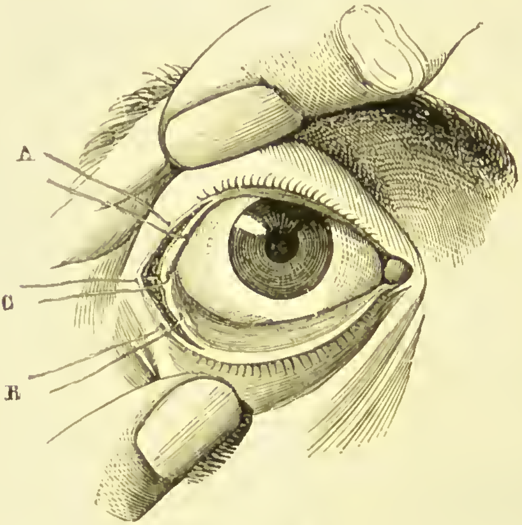

FIG. 139 (*de Wecker*).

Blepharophimosis (*βλέφαρον, eyelid*; *φίμωσις, narrowing*) is a contraction of the outer commissure of the lids, with consequent diminution in size of the opening between the latter; and is commonly due to shortening of the skin, from long-continued irritation of it, caused by the discharge in a case of very chronic conjunctivitis.

It is remedied by a *Canthoplastic Operation.* The outer commissure is divided in its entire thickness, in a line which is a prolongation of the line of junction of the lids when closed, by a single stroke of a strong straight scissors, one blade of which has been passed behind the commissure. The integumental incision should be made a little longer than that in the conjunctiva. An assistant then draws the upper lid up and the lower lid down, so as to make the wound gape. The conjunctival margin and the dermic margin are now united in the centre by a point of suture (C, Fig. 139), while two more sutures (A and B) are applied, one above and the other below the first. This operation is also employed in cases of granular ophthalmia and of purulent conjunctivitis, when it is desired to relieve pressure of the eyelid on the globe.

Distichiasis (δίς, *twice;* στίχος, *a row*) and **Trichiasis** (τρίχος, *a hair*).—The first of these terms indicates the growth of a row of eyelashes along the intermarginal portion of the lid in addition to the normal row; while trichiasis indicates a false direction given to the true cilia. Both conditions are often found co-existing, and often, too, they are present along with entropium. They may both be produced by chronic blepharitis (p. 276), or by chronic granular ophthalmia (p. 162). Some cases of congenital distichiasis and trichiasis have been recorded. The symptoms the false cilia produce, and the dangers to the eye attendant on them, are due to their rubbing on the cornea, which causes pain, blepharospasm, and opacity of the cornea, or even ulceration of it.

Operations for Distichiasis and Trichiasis :—

Epilation.—The false cilia may be pulled out with a forceps; but this cannot be regarded as a cure, for the hairs grow again.

Electrolysis.—A needle is attached to the negative pole, and its point passed into the bulb of the eyelash to be removed, the positive pole being placed on the temple. On closure of the circle, if the battery be working properly, bubbles of gas should rise up round the needle, and a slough forms at the root of the hair, which becomes loose, and is removed. It does not grow again, for the bulb is destroyed. Each hair must be separately operated on. The proceeding is very valuable where only a few cilia are to be dealt with.

Excision.—When some half-dozen hairs close together are growing wrong, the simplest and best plan is to completely remove them by excision of the corresponding portion of the ciliary margin. A fine knife is passed into the intermarginal region at the place corresponding to the hairs to be dealt with, and a partial division of the lid into two layers, as in the Arlt-Jaesche operation (*vide infra*), is effected. A V-shaped incision in the skin of the lid is then made, including the erring hairs, the whole flap is excised, and the margin of the loss of substance drawn together with sutures.

In cases of distichiasis or trichiasis involving the whole length of the eyelid, removal of the marginal portion of skin containing the bulbs of all the eyelashes, true and false (Flarer's operation), is not to be recommended—unless, occasionally, in the underlid—because it unnecessarily deprives the eye of an ornament, and of a protection against glare of sun and foreign bodies.

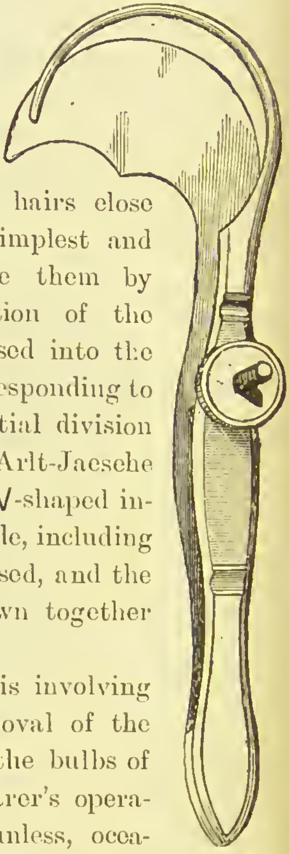

FIG. 140.

Transplantation, or *Shifting*, of the marginal portion of the integument containing the hair bulbs, true and false. One of the oldest and most valuable operations of this kind is that of Jaesche, modified by Arlt. It is performed as follows:—Knapp's, or Snellen's, clamp (Fig. 140) having been applied to prevent bleeding, the lid in its whole length is divided in the intermarginal part into two layers (Fig. 141), the anterior containing the orbicular muscle and integument with all the hair bulbs, the posterior containing the tarsus and conjunctiva. The incision in the intermarginal portion is about 5 mm. deep. A second incision is now made through the integument of the lid, parallel to its margin, and from 5 to 7 mm. removed from it. This incision also extends the whole length of the lid. A third incision is carried in a curve from one end to the other of the second incision. The height of the curve is proportional to the effect required, varying from 4 mm. to 7 mm. The piece of integument included between the second and third incisions is dissected off with forceps and scissors, without any of the underlying muscle being touched, and the margins of the loss of substance are brought together by sutures. By this procedure the lower portion of integument, containing the hairs and their bulbs, is drawn up and away from contact with the cornea.

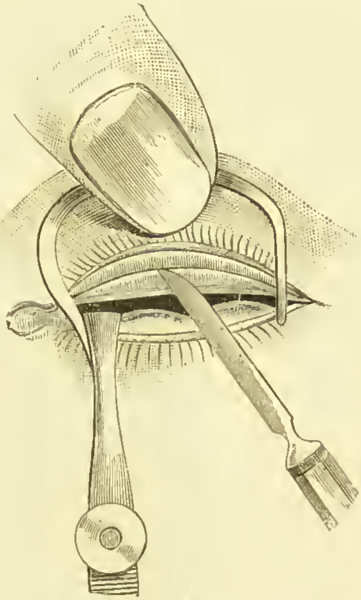

FIG. 141.

Van Millingen's Operation consists in splitting the eyelid, as in the Arlt-Jaesche operation, from end to end, sufficiently to produce a gap (*B*, Fig. 142) 3 mm. in width at the central part of the lid, and gradually becoming narrower towards the canthi. The gap is kept open by sutures passed through folds of skin on the upper lid (*a a a*), by means of which also the lid is prevented from closing for twenty-four hours at the least. As soon as the bleeding has ceased, a strip of mucous membrane of the same length as that of the lid, and

2 to 2½ mm. in breadth, is cut out with two or three snips of a curved scissors from the inner surface of the patient's underlip, on which a Knapp's clamp has been placed to prevent bleeding, and is introduced at once into the gap in the intermarginal space. It should then be pressed into position with a probe. According to Van Millingen, sutures are superfluous; but they are desirable for the sake of security, and do no harm. It is important, in order to obtain a neat effect, to clean the fat and submucous tissue from the flap before applying it; while this is being done the flap should lie on a warm porcelain plate. The eyelid is then covered over with a piece of lint, on which is spread a thick layer of xeroform vaseline, and over this is placed a wad of cotton-wool and a bandage.

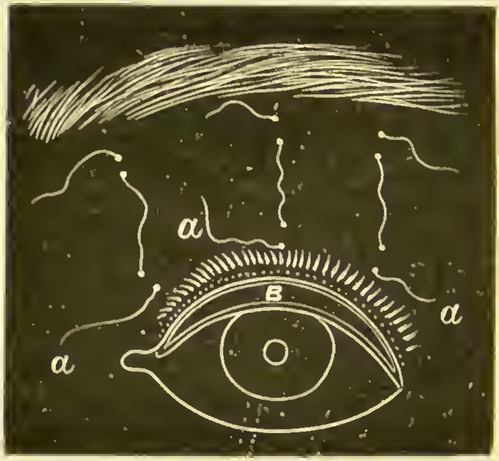

FIG. 142.

It is not advisable to transplant small strips of mucous membrane if the trichiasis be partial, as partial trichiasis is often only the commencement of complete trichiasis, and therefore, in these cases, the filling up of the entire length of the intermarginal space with a flap of mucous membrane should be effected. One or two fine sutures, which serve to unite the margins of the wound in the lip, arrest the bleeding at once, and accelerate union of the part, which is generally completed in twenty-four hours.

This method is very effectual in permanently providing a good intermarginal space, and in thus definitely relieving the condition.

Entropium (*ἐν, in ; τρέπω, to turn*), or **Inversion of the Eyelid,** is due to organic change in the conjunctiva or tarsus, or to spasm of the palpebral portion of the orbicular muscle. A large proportion of the former class of cases is the result of chronic granular ophthalmia, and is most common in the upper lid. Spastic entropium occurs in the under lid only. It is frequent in old people (senile entropium) from relaxation of the skin of the eyelid, and is also produced by the wearing of a bandage after operations.

Treatment.—Organic entropium, in which the tarsus of the upper lid is not distorted, can often be corrected by one of the methods described for trichiasis and distichiasis. But many of these cases are accompanied by, or rather are due to, abnormal curvature with hypertrophy of the tarsus.

In such cases the operation must include an attack on the tarsus itself.

Snellen's Operation.—Knapp's clamp is applied. About 3 mm. from the margin of the lid, and parallel to it, an ncision is made through the skin alone, extending the whole ength of the lid. The orbicular muscle is exposed by dissection of the skin upwards, in order to promote retraction of the latter, and along the edge of the lower margin of the wound a strip about 2 mm. broad of the orbicular muscle s removed, and the tarsus to the same extent is exposed to view. A wedge-shaped piece, corresponding to the exposed part of the tarsus, is now excised from it with a very sharp calpel, the edge of the wedge pointing towards the conjunctiva, which latter, however, is left intact. The hypertrophy of the tarsus, which is always present, facilitates this procedure. A silk suture carrying a needle on each end having been prepared, one needle is passed from within outwards through the band of muscle and integument left at the margin of the lid. The second needle is also passed from within outwards through the upper lip of the tarsal loss of substance, and then from within outwards through this same marginal band, at a distance of about 4 mm. from the point of exit of the first needle. The ends of the suture are now tied together, a small bead having first been strung on each to prevent it from cutting through the skin. Three such sutures are employed. The accompanying figures (143 and 144) make the foregoing description more intelligible.

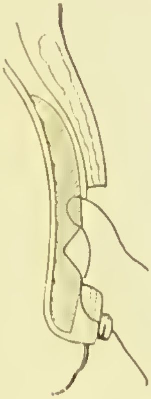

FIG. 143.

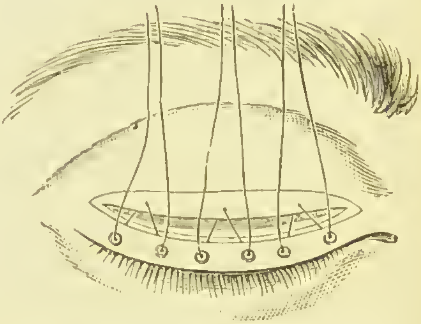

FIG. 144.

Berlin's Operation.—Knapp's clamp is applied. The first incision lies 3 mm. above the margin of the lid, extends its whole length, and divides it in its entire thickness, including the conjunctiva. The skin and muscle at the upper edge of the wound are pushed or dissected up so as to expose the tarsus. The upper edge of the tarsal incision is now seized at its centre with a finely toothed forceps, and an oval piece with the adherent conjunctiva, about 2 to 3 mm. wide in its widest part, and in length corresponding with that of the eyelid, is excised from it with a fine scalpel. The wound is closed with three sutures through the skin. If it be thought desirable to increase the effect, a skin-flap may be excised from the lid. The objection to this operation, that a portion of the mucous membrane is removed, is not of importance. The method is a good one.

Spastic Entropium of the lower lid, as the result of bandaging, usually disappears when the use of the bandage is given up, or, if the bandage must be continued and should the inverted lid cause irritation, a dermic suture at the palpebral margin and fastened to the cheek below will give relief.

Senile Entropium of the lower lid is, of the spastic kinds, the one which most commonly demands operative interference. The methods in general use for it are :—

The Excision of a Horizontal Piece of Skin, with a portion of the underlying palpebral part of the orbicular muscle, so as to give rise to sufficient cicatricial contraction to draw the margin of the lid outwards. Unfortunately this often does not effect a permanent cure, relapse taking place after a time.

The foregoing, and other such measures, produce a good result at the time, but are sometimes followed by recurrence of the entropium. Hotz believing the cause of this to be that the cicatrix, whether dermic or dermo-muscular, upon which the result depends has no *point d'appui*; and consequently, while it may draw the eyelid out, is liable to draw the skin of the cheek up, and thus to neutralise its desired effect, has proposed the following ingenious operation :—

Hotz's Operation.—A horn spatula is inserted under the lid, and then, at 4 to 6 mm. below the margin of the latter, a horizontal incision is made through the skin from the inner to the outer end of the lid. This incision is at the boundary

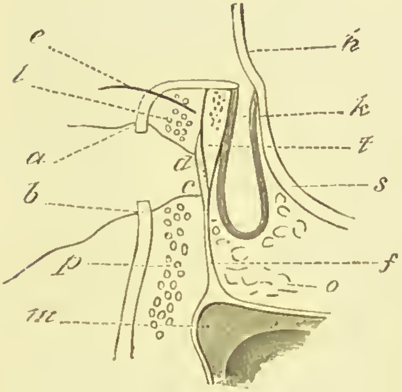

FIG. 145.

between the palpebral and orbital portions of the orbicular muscle, and just over the lower margin of the tarsus. An assistant then draws the upper edge (*a*, Fig. 145) of the wound upwards with a forceps, while the surgeon draws the lower edge (*b*) downwards, in this way exposing and stretching the orbicular muscle. A few strokes of the knife in the direction of the incision are now sufficient to separate the palpebral portion (*l*) of the muscle from the orbital portion (*p*), and to lay bare the lower edge of the tarsus (*t*), which has a yellowish tendinous appearance. That part of the palpebral portion of the muscle which covered the lower edge of the tarsus, and which was drawn up with the palpebral edge of the first incision, is now removed with forceps and scissors, to the extent of about 2 mm. in width, through the whole length of the lid. All such muscular fibres, also, which may still adhere to the lower third of the tarsus must be carefully cleaned off, and now the palpebral skin may be brought into union with the tarsus. Four sutures are generally applied, about 5 mm. apart. The needle is passed through the palpebral skin, close to the margin of the wound (at *a*). The bare tarsal edge is then seized in the forceps, the needle placed perpendicularly on it (at *d*), and carried through it by a short downward curve until its point appears (at *c*) below the tarsus in the tarso-orbital fascia (*f*). The needle is now passed out through the lower edge of the incision (at *b*), care being taken that none of the fibres of the orbital portion of the muscle are included in the suture. Upon the suture being tightly closed, the edges of the skin wound are drawn into the tarsus, and become adherent to it. The sutures may be removed about the third day. If the first incision be placed too far from the margin of the lid, there will be no result, as the traction upon the palpebral skin will be too slight. If the incision be placed too close to the margin, the traction may be so great as to interfere with the union of the skin and tarsus. In this operation the tarsus affords the fulcrum, which Hotz thinks is wanting in other methods. The tarsus of the lower lid is sometimes very little developed, and then we find that the result of the operation may be disappointing.

Ectropium or **Eversion of the Eyelid.**—Of this there are two chief kinds: (1) Muscular, or Spastic, which affects the lower lid only; (2) Cicatricial.

Muscular ectropium occurs only in the lower eyelid and may have its starting point in œdema of the conjunctiva, which everts the edge of the eyelid, and this eversion becomes increased and encouraged by spasm of the palpebral portion of the orbicular muscle, so that the term palpebral paraphimosis might be given to the condition. In the recent stage it may generally be remedied by suitable conjunctival measures. In chronic cases operative measures are usually required.

Muscular ectropium is often seen in old people, and is then given the name of Senile Ectropium. Here it is due to atrophy of the palpebral portion of the orbicularis of the lower lid, and relaxation of the skin of the face. When these have resulted in slight eversion of the inferior punctum, a flowing of tears is produced, causing some excoriation of the skin and edge of the lid, which then increase the tendency to ectropium. If the condition be not extreme, with secondary changes in the conjunctiva, slitting up of the canaliculus, with the use of a boric ointment for the lids and mild astringents for the conjunctiva, will give much relief. In pronounced cases a more active treatment of the conjunctiva, and the performance of tarsoraphy, or the application of Snellen's sutures, or one of the other operations described below, are demanded. Muscular ectropium is also caused by paralysis of the orbicular muscle.

Snellen's Sutures.—A silk ligature is threaded at either end with a needle of moderate size and curve. The point of one of these needles is passed into the most prominent point of the exposed and everted conjunctiva, and brought out through the skin 2 cm. below the edge of the lower lid. The other needle is entered in the same way 5 mm. from the first, and made to take a nearly parallel course, the points of exit on the cheek being 1 cm. apart. Equal traction is applied to each end of the suture, while the lid is assisted into its place by the finger. The suture is tied on the cheek, a small roll of sticking-plaster having been inserted under it, to protect the skin from being cut. Two, or even three, such sutures may be required, and they are allowed to remain for several days.

Freeland Fergus' Method.—Fergus points out that the two-thirds of the exposed conjunctival surface of the lower eyelid, from the fornix towards the free margin, are usually comparatively healthy, the marginal third alone being diseased. He has devised the following procedure, which consists in excision of the diseased tissue. An incision is made through the conjunctiva from the inner to the outer canthus, demarcating its healthy from its diseased portion. With forceps and scissors the conjunctiva covering the healthy portion of the eyelid is freed from the underlying structures right down to the region of the retro-tarsal fold. The hypertrophied tissue is next excised throughout its entire extent, so as to restore as it were the original margin of the lid, and finally the conjunctiva is drawn up and secured by a few points of suture to the margin. The success of the operation depends on the thoroughness with which the excision of the hypertrophied tissue is carried out.

Kuhnt's Operation for Senile Ectropion is an admirable one. It consists in splitting the lower lid in its central third, so that the conjunctiva and tarsus are left in the posterior layer, while the anterior layer contains the orbicularis and the skin. A triangular piece, the base of which is formed by the margin of the lid, is then excised from the posterior layer, and the margins of the loss of substance in the latter are brought together by three or four points of suture. Lest they should give way too soon, it is necessary to place these sutures very securely. A puckering of the anterior layer, opposite the line of sutures in the posterior layer, is produced, but subsequently disappears, and a suture which unites the most prominent point of the pucker and the margin of the tarsus assists in this. Or, if the lid be split, say, to an extent twice as long as the base of the triangular piece to be excised, the puckering can be distributed at either end of the incision. By reason of the shortening of the lid as the result of this excision the eversion is corrected. We frequently use this operation, and always with gratifying results.

Kenneth Scott's Operation.—The external canthus and tissues beyond are thoroughly divided by a pair of strong scissors. The lower eyelid, which is usually the affected one, is then seized and its margin stretched sufficiently outwards, parallel to the border of the other lid, so as to restore the palpebral aperture to its proper appearance; the portion of eyelid margin thus made to extend beyond the site of the external canthus is removed, along with its contained eyelashes, by slicing it with a sharp knife. The upper and lower eyelids are then brought together, so that the original outer extremity of the upper eyelids approximates exactly to the new extremity of the lower eyelid. They are secured in this position by passing a silver wire suture vertically downwards through the substance of the upper lid, continuing it out through that of the lower one, and then twisting the ends firmly together. Two of these retaining stitches may be introduced close together if necessary. The edges of divided skin, along with the deeper muscular tissues, including that part which recently formed the outer end of the affected eyelid, are simply stitched together with a continuous fine silk suture.

No dressing other than a repeated dusting with some fine antiseptic powder need be used. The silk stitches may be removed in six days' time, the silver ones being left in for five or six days longer. Scott states there is never any puckering apparent beyond the newly formed canthus, and the small linear cicatrix is lost amongst the other lines often found there.

Cicatricial ectropium is caused by scars in the eyelid from caries of the orbit, or from wounds or burns, which destroy the integument of one or both eyelids. A common event is cicatricial ectropium caused by burns of the face which epileptics or children who have fallen into the fire have acquired. In these cases the burnt skin is replaced by a granulating surface, and when cicatrisation of this commences the free margin of the upper lid is drawn up towards the eyebrow, and that of the lower lid down towards the cheek, the conjunctival surface of the eyelids in consequence becoming everted, and the cornea exposed, as the eyelids cannot now be closed.

Many operations have been proposed for the relief of this condition, but the only one we recommend is that by *Skin Transplantation after the Method of Wolfe.* It is performed as follows:—

In the first place the eyelid—let it be the upper eyelid—is dissected down into its place to the utmost limit, so that the most extensive raw surface possible may be obtained. The margin of the lid, having been drawn over the lower lid, is fastened to the cheek with three points of suture. A portion of skin, suited as regards shape, and about one-third larger (to allow for shrinkage) than the raw surface of the eyelid, is then taken from the inside of the arm, and having been carefully freed of all its subcutaneous fat and connective tissue, is laid upon the raw surface, and secured to it by a large number of fine interrupted sutures around the margin. Or, if the margin of the skin surrounding the raw surface be dissected up, the edge of the graft can be slipped under it, and secured in its place by this means. A non-irritating dry or ointment dressing is applied, and the graft usually heals on in the course of a few days. This method of grafting was introduced by Wolfe and Lefort, and we employ it in all these cases with most satisfactory results.

It is important to preserve and utilise any part of the skin of the eyelid which remains, especially its ciliary border with the eyelashes. The thorough cleaning of the flap from its subcutaneous fat and connective tissue is also important, as otherwise an unsightly and lumpy effect is produced when the flap has healed on. While this cleaning is being done the flap should lie on a warm sterilised porcelain plate. The flap should not be applied to the raw surface until all oozing of blood from the latter has ceased, but this is usually the case by the time the operator has prepared the skin flap from the arm.

The transplantation of a flap with pedicle from the forehead, temple, or cheek is also used to repair an eyelid; but, owing to the thickness of the integument, the result is cosmetically less satisfactory than that given by a graft from the arm, while the tendency to shrink is quite as great.

Some prefer Thiersch grafts to dermic grafts, and state they are more easily applied to the raw surface, and do not differ in colour from the surrounding skin when healing is completed. It is desirable to obtain one continuous graft of the whole size of the wounded surface.

***Ankyloblepharon** (*ἀγκύλη, a string; βλέφαρον, an* *eyelid*) is a uniting of the upper and lower eyelids along their margins. It may be partial or complete, and often goes with symblepharon. Like the latter, it is usually caused by burns and ulcers.

The condition can only be relieved by operation, of which the result is often unsatisfactory, owing to the difficulty of preventing re-union taking place at the canthi. To avert this it is always necessary to cover the wounded surface with conjunctiva or skin.

Injuries of the Eyelids.—All kinds of injuries of the eyelids (contusions, incisions, burns, etc.) are common.

In consequence of the looseness of the integument, œdema and ecchymosis, one or both, are often seen in a marked degree as the result even of slight injuries.

Owing to the direction of the fibres of the orbicularis, an incised wound of the eyelid, if in the vertical direction, will gape, while a similar wound in the horizontal direction will not do so. Hence the scar left after the former wound is apt to be very visible, but that after the latter may be almost imperceptible. If the eyelid be divided vertically in its entire thickness, unless union by first intention can be obtained, a deep furrow is left in the eyelid, and, perhaps, at its margin an unsightly coloboma.

The result of burns of the eyelids has been treated of at p. 316.

Emphysema of the eyelids is sometimes seen after a blow on the eye, and is a sign of fracture of the orbit, with a communication between the subcutaneous connective tissue of the eyelids and the nose, the ethmoid sinus, the frontal sinus, or the antrum of Highmore. An emphysematous lid is swollen, soft, and crepitating to the touch.

Ecchymosis of the lower lid, usually with ecchymosis of the lower portion of the conjunctiva, after falls or blows on the head, is a sign of fracture of the base of the skull, the blood making its way along the floor of the orbit.

Simple ecchymosis of the eyelids from blows, commonly known as 'black eye,' never gives rise to further complication. It requires some fourteen days or more, according to the quantity of blood extravasated, before the eye recovers its normal appearance.

Treatment.—Injuries of the eyelids, of whatever kind, are of course treated upon general surgical principles. Incised wounds should be carefully and neatly drawn together with sutures as soon after the injury as possible, and with antiseptic precautions. Emphysema may be assisted in its absorption by the application of a rather tight bandage, and directions should be given to the patient to blow his nose as gently as possible, so as to avoid recurrence of the condition.

***Epicanthus** is a congenital deformity, usually binocular, which, in the most pronounced cases, consists in partial paralysis of the levator palpebræ (ptosis) (see chap. xviii.) and of the rectus superior, with a narrow palpebral fissure, and a fold of integument at the inner canthus concealing the caruncle from view, and giving the appearance of great breadth to the bridge of the nose. The term is also used for cases in which the integumental fold at the inner canthus is the only abnormal condition, and this deformity can be somewhat diminished by the removal of an oval piece of skin from the bridge of the nose, its long axis being vertical and its width varying according to the effect required. When the margins of the wound are brought together the abnormal folds are diminished in width.

***Congenital Coloboma** of the upper lid—sometimes associated with a dermoid cyst of the limbus of the cornea corresponding to the cleft in the lid—and even congenital absence of the eyelids, have been occasionally observed.

CHAPTER IX.

DISEASES OF THE LACRIMAL[1] APPARATUS.

Malposition of the Punctum Lacrimale.[2]—The punctum in the lower lid is more efficient than that in the upper lid for carrying off the tears, and a derangement of the lower punctum alone is sufficient to give rise to epiphora. Inversion of the punctum accompanies entropium of the lower eyelid, while eversion of it is present with ectropium of the lid. A slight eversion, quite sufficient to cause epiphora, may exist without any marked ectropium of the lid, and it is these cases which more properly belong to this chapter. They are the result generally of some chronic, although it may be slight, skin affection of the lower lid, which draws the inner end of the latter a little away from the eyeball.

A prominent symptom of this and of all the following lacrimal affections is lacrimation, or epiphora (*ἐπιφορὰ δακρύων, a flow of tears*), a flowing of tears over the cheek.

Treatment. Inversion of the punctum can only be relieved by an entropium operation on the eyelid. For the treatment of eversion of the punctum, see below.

Stenosis, and **Complete Occlusion of the Punctum Lacrimale.**—Either of these conditions may result from conjunctivitis, or from marginal blepharitis, although they may not appear for a length of time after those affections have passed away, and the original affection may have been so slight as to have escaped the observation of the patient. In stenosis the size of the punctum may become so extremely minute, that even the normal flow of tears is too copious to pass through it. Complete occlusion is probably only a more advanced stage of stenosis.

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[1] *Lacrima*, a tear.

[2] In this chapter, and elsewhere in the book, the terms punctum lacrimale and canaliculus refer to the inferior passage, unless it be otherwise expressly stated.

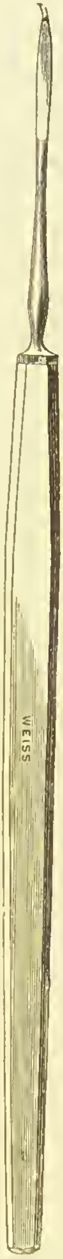

FIG. 146

The Treatment, in cases of eversion of the punctum where there is no marked ectropium of the lid, of stenosis, and of complete occlusion, is similar, namely, the opening up of the punctum, and its conversion into a slit. This is done with a Weber's knife (Fig. 146), the probe-point of which is passed into the punctum in cases of eversion, forced into the small opening in cases of stenosis, or forced through the usually thin covering of the punctum in cases of occlusion. In doing this the lower lid should be stretched tightly by a finger of the surgeon's left hand placed near the external canthus. The probe-point having entered the punctum, the edge of the knife is turned slightly towards the eyeball, and the instrument is pushed on into the canaliculus, until 2 mm. of the latter has been opened up, and is then withdrawn. If the edge of the knife be directed outwards in this proceeding, the incision comes to lie on the outer edge of the intermarginal portion of the lid, and not in contact with the eyeball; consequently the result is unsatisfactory, for the tears are not carried away, and moreover the disfigurement produced is considerable. A slitting up of the whole, or the greater part, of the canaliculus in these cases is unnecessary, and interferes with the physiological action of the tear passage. For two or three days after the little operation, it is necessary to pass a probe daily along the portion of the canaliculus which has been slit up, to prevent union taking place.

When, as sometimes happens in old people, and occasionally even in the middle-aged, from relaxation of the orbicularis the inner end only of the under lid is everted, the excision of a small flap of conjunctiva somewhat after the manner of Fergus (p. 314) will restore the punctum to its normal position.

Obstruction of the Canaliculus.—The canaliculus may be diminished in its calibre, or entirelyclosed, by contraction, the result of inflammation which has extended to it from the conjunctival sac. It is not possible to diagnose the presence of either of these conditions, which may be associated with stenosis or occlusion of the punctum lacrimale, except by the introduction of a very fine probe into the canaliculus. The passage may also be obstructed by an eyelash, a chalky deposit, or a mass of streptothrix.

The diagnosis of streptothrix in the inferior canaliculus—it rarely affects the upper canaliculus—is made by the following signs and symptoms:—Lacrimation; the presence of a creamy-yellow discharge at the inner canthus, without dacryocystitis; congestion of the caruncle and neighbouring parts of the conjunctiva. On everting the inner end of the lower lid, the region corresponding to the canaliculus is seen to be rounded and swollen on its conjunctival aspect. The lacrimal punctum is enlarged, stands out from the eyeball when the patient looks up, and is filled with creamy exudation. On palpation, a hard cylindrical mass can be felt in the canaliculus. At a later stage, severe purulent inflammation of the canaliculus comes on, with marked swelling of the eyelid in the neighbourhood, and pain. The greenish-yellow dacryolith contained in the canaliculus usually consists of a streptothrix, which some regard as actinomyces.

Treatment.—Where there is merely diminution in the calibre of the passage, the introduction of probes, increasing in size, is frequently sufficient to effect a cure. If dilatation fail, recourse must be had to slitting up the canaliculus; but, if it can possibly be avoided—that is, if a less extended opening will answer—the passage should not be slit up in its entire length. At least 3 mm. of its median end ought to be left intact, as otherwise regurgitation of tears from the lacrimal sac is liable to trouble the patient ever afterwards. If the canaliculus be completely closed by adhesions, so that a fine probe cannot be pushed through it, it becomes necessary to rip it up with the point of any small knife, following the known course of the passage from the outside. If the canaliculus be closed as far as the opening into the sac, or if only at that point, the obstruction must be pierced with the point of a fine knife. A difficulty in all these cases is to keep the passage patent when once formed. A plan which affords tolerable certainty of this is the frequent passage of probes into the sac until the tendency to closure seems to have ceased; but even under favourable conditions recurrences of the closure are apt to occur.

Streptothrix in the lower canaliculus is readily cured by slitting up the passage and evacuating its contents.

Stricture of the Nasal Duct is usually the result of simple swelling of its mucous membrane in a catarrhal attack, which has originated in the nasal mucous membrane; or, of membranous or cicatricial contraction of the mucous membrane resulting from long-continued catarrh. It also occurs in consequence of disease of the bones of the nose—*e.g.*, in syphilis, acquired or congenital, and from blows which fracture the bridge of the nose.

Treatment.—It is desirable to commence the treatment by syringing the nasal duct, the fine point of an Anel's syringe being introduced into the punctum lacrimale and canaliculus. By this means the presence or absence of a stricture is ascertained—the fluid, if there be no stricture, passing freely into the nostril. In some cases, where the obstruction is merely a plug of mucus, a cure may at once be effected. Stricture due to acute inflammatory swelling of the mucous membrane should be treated by the injection of weak alum or other astringent solutions into the lacrimal sac, or down the nasal duct, by means of an Anel's syringe, and attention should be paid to the nasal mucous membrane. Probing here should not be attempted, lest it injure the delicate swollen mucous membrane of the duct.

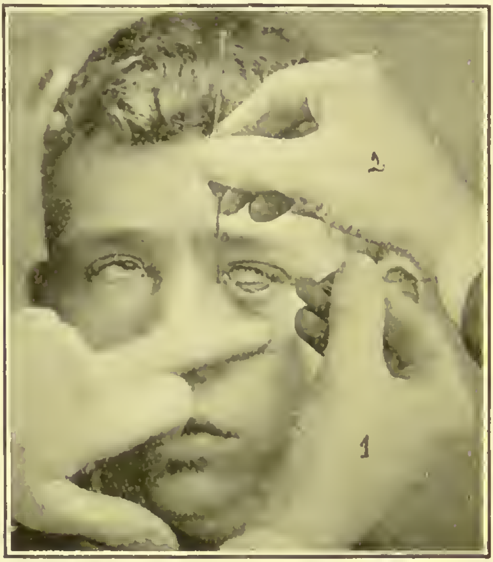

FIG. 147.

Membranous or cicatricial strictures are best treated by means of probes in the manner proposed by Sir William Bowman. The inferior canaliculus is slit up to a slight extent so as to admit the point of one of Bowman's smallest probes, which is given a curve to suit that of the nasal duct. With a finger of the left hand (Fig. 147), if it be the patient's left eye, the surgeon stretches the lower lid, and, entering the probe with the right hand into the canaliculus, pushes it gently along its floor until the point reaches the lacrimal bone (Fig. 147, position No. 1). The point being kept pressed against this bone, the direction of the probe is now altered, by carrying its free end upwards towards the bridge of the nose, until its point in the lacrimal sac is directed towards, or aimed at, the sulcus between the ala of the nose and the cheek. The probe, then, in this position (Fig. 147, position No. 2) corresponds to the prolonged axis of the nasal duct, down which it is pushed slowly and with gentle pressure. If it be the right eye, the surgeon reverses his hands, or operates from behind the patient. Any obstacles met with are overcome, if possible, by an increase of the pressure; but if, at any part of the passage, much difficulty be encountered, rather than that any violence be used, all further manipulation should be postponed to another day; and it will often be found that at the second or third visit the probe is passed with comparative ease. Thicker probes are gradually introduced at successive sittings, until the largest size has been reached.

The most common seats for membranous or cicatricial stricture of the nasal duct are at its upper end, where it enters the sac, and where it is narrowest; and at its lower end, where it is most exposed to catarrhal processes spreading from the nostril.

Should there be reason to think that the stricture is due to chronic catarrhal swelling of the lining mucous membrane of the duct, astringent injections into the canal, in addition to probing, are of use.

Weber's probes are conical, and of very large calibre at their thickest part. The objection to such large probes is that when passed into the nasal duct, their thickest part, which is 3 to 4 mm. in diameter, corresponds with the upper end of the duct, which is its narrowest part, being only 3 mm. in diameter. Consequently, the probe becomes more or less impacted at this place at each operation, and this impaction, from injury of the mucous membrane and periosteum, is liable ultimately to give rise there to hypertrophy of the periosteum, and finally to stricture; so that, while the immediate effect of their use is perhaps even brilliant, the ultimate result is often the very reverse. When used by the inferior canaliculus, their size makes it necessary to slit that passage in its entire length, and the entrance of the passage into the sac must be enormously dilated by so large an instrument, both of which circumstances are most undesirable. The same objection applies to the large probes introduced by Theobald. Syringing the nasal duct should not be performed after passing a probe, lest cellulitis be set up.

To prevent closure of the duct when once made free, Mr. Arthur Benson advocates the use of leaden styles, removable by the patient. He first divides the canaliculus (by preference the upper one), and dilates the stricture with probes in the ordinary way, and then introduces into the duct a piece of leaden wire 1·5 mm. to 2 mm. in diameter, cut to length, and smoothed off at the ends. The upper end is curved so as to lie out on the cheek. The style is at first removed daily, and the duct syringed, until any existing inflammation and discharge have almost ceased. The intervals are then increased; and as soon as practicable the patient is taught to remove the style and to replace it himself. When he is able to do this easily, he is directed to leave the style out for some hours each day, and finally to wear it only at night.

Very obstinate membranous strictures can sometimes be freed by electrolysis.

The most favourable cases of stricture for cure are those due to inflammatory swelling of the mucous membrane, and next in order come those caused by membranous or cicatricial contraction, while those due to bony obstructions must be regarded as incurable.

Now and then cases of persistent lacrimation will be met with, in which the nasal duct and the rest of the lacrimal apparatus are in perfect order. These cases are often due to a catarrhal affection of the nasal mucous membrane, slightly involving the very lowest extremity of the nasal duct. Applications directed towards relief of the nasal affection are here indicated.

Blennorrhœa of the Lacrimal Sac, or **Chronic Dacryocystitis,** is commonly caused, in the first instance, by stricture of the nasal duct. In consequence of this stricture the tears and the normal mucous secretion of the lining membrane of the sac are retained, and offer favourable conditions for the growth of micro-organisms, of which the pneumococcus is the one usually present.

But cases of lacrimal blennorrhœa are seen in which no stricture of the nasal duct is found. In many of these cases there has been a stricture due merely to catarrhal swelling of the lining membrane of the duct, which has subsided in the course of time without treatment, and the duct has then again become free, while the lacrimal blennorrhœa to which the stricture gave rise continues. It is very probable, however, that lacrimal blennorrhœa may occasionally come on where there has never been a stricture of the nasal duct, and merely as an extension of catarrh from the nostrils, especially in cases of ozæna, or as an extension of catarrh from the conjunctiva.

Tubercle is occasionally the cause of dacryocystitis, but it is not possible to make a clinical diagnosis between these and the more common cases, if, as in a few recorded instances, the mucous membrane of the lacrimal sac alone be diseased. In nearly all cases the tubercular infection of the sac extends from the nostril, or from the conjunctiva, one or other of which is the primary seat of the disease.

Symptoms.—The patients usually complain of nothing more than lacrimation. Those who are more observant of themselves may have noticed a swelling, known as a lacrimal tumour or mucocele, in the region of the lacrimal sac; and also that the conjunctival sac, especially when the swelling is pressed upon, becomes now and then more or less filled with a somewhat thick and opaque discharge, which obscures the sight until wiped away. Occasionally there is no lacrimal tumour, for the contents of the sac may not be copious enough to distend it markedly.

In order to ascertain in each case of epiphora whether or not lacrimal blennorrhœa be present, the surgeon presses with his finger over the lacrimal sac, when, if there be blennorrhœa, the discharge will be evacuated through the puncta into the conjunctival sac. In those cases in which there is no longer a stricture of the nasal duct, the discharge may pass downwards into the nose, and the patient will feel it in his nostril, out of which he can then blow it.

Conjunctivitis must sometimes be regarded, not as the cause, but rather as the effect of a lacrimal blennorrhœa, by reason of the discharge from the lacrimal sac making its way into the conjunctival sac. Blepharitis, too, is seen as a further result of irritation from the discharge in old-standing cases.

The most serious complication of chronic dacryocystitis is the serpiginous ulcer of the cornea, caused through infection by the pneumococcus (see p. 225).

Treatment.—It is important, in the first place, to ascertain whether there be a stricture of the nasal duct, and for this purpose water should be injected by means of an Anel's syringe through the canaliculus into the duct. If the fluid make its way freely into the nose or pharynx, it may be taken for granted that the nasal duct is not obstructed; but if, instead of passing through—or only under high pressure—it distend the lacrimal tumour to a greater size, a stricture may be assumed. If stricture of the nasal duct be present, it must be relieved, or all other measures will prove futile. Should there be no stricture, and also before and after any existing stricture has been freed, the treatment consists in the very frequent pressing out of the contents of the sac by the patient, so that no distension of it may occur: and in doing this he should endeavour to cause the discharge to pass down the nose rather than into the eye; while the surgeon, having, if necessary, dilated the canaliculus, injects astringent solutions into the sac daily, to relieve the catarrh. Protargol, in a 15 or 20 per cent. solution, is a useful application for introduction into the lacrimal sac. The latter should first be washed out with a physiological salt solution. Other fluids which have been recommended are Sol. Argyrol 25 per cent., Sol. Hydrarg. oxycyanat. 2 per cent., Sol. Potas. perman. 1 in 2,500.

The caustic treatment (recommended further on for acute dacryocystitis) is often of the greatest benefit in these chronic cases. Any existing conjunctivitis or nasal catarrh should be treated. But there are many cases in which no treatment, short of obliteration or extirpation of the lacrimal sac, will bring about a radical cure of this very troublesome complaint.

Obliteration of the sac can be done by the application of a galvano-cautery to the lining membrane of the sac, but it is a most unsatisfactory proceeding.

**Extirpation of the lacrimal sac* is a far preferable proceeding, and for it Kuhnt's method is probably the best.

Prior to the operation the contents of the sac should be expressed, and its cavity washed out with a sterilized salt solution. To render the sac more easily found, some surgeons fill it out with paraffin prepared for surgical use with a melting point of 110°, which is injected with a paraffin or other syringe through the lower canaliculus. The paraffin at once hardens, and the sac becomes outlined.

It is necessary that the patient should be deeply anæsthetised, or an effectual local anæsthesia may be obtained as follows:—About ten minutes before the operation a few drops of the following solution is injected subcutaneously: three drops of a 1 in 1,000 solution of adrenalin, to which is added 1 c.cm. of a 1 per cent solution of cocaine. After the injection it is necessary to wait until the field of operation becomes of a waxy whiteness. The operation can then be performed almost painlessly. By this means too, the hæmorrhage is reduced to a minimum. As a result of the injection slight œdema of the region may be seen a few days after the operation, and a rather tight bandage should be applied, as there may be some hæmorrhage when the vascular contraction gives way.

An incision down to the bone and about 2·5 cm. long is made over the anterior lacrimal crest. It begins 4 mm. above the internal palpebral ligament, and ends 5 mm. below the commencement of the bony lacrimal duct. As a rule the palpebral ligament is not divided by this incision, and has now to be separated with the scissors close to its insertion. Müller's speculum is then inserted to draw aside the lips of the wound, and Axenfeld's speculum in inserted from the nasal side into the upper and lower angles of the wound as deep as the periosteum, to check the troublesome hæmorrhage which proceeds mainly from those angles (Fig. 148). If there be bleeding from the small arteries, they are seized and twisted. The fibrous capsule of the sac is carefully incised along the crest, care being taken that the sac itself is not opened. The anterior wall of the sac, greyish blue and shining when no paraffin has been injected, then becomes exposed in the cavity. To remove the sac the surgeon separates its inner wall from the periosteum with the closed blunt ends of the scissors; then the fundus of the sac, along with the strong fibrous capsule which is here adherent to it, is drawn forwards, and with a few strokes of the scissors is separated from its bed, and the scissors are passed behind the sac from above and the posterior wall similarly separated. The fundus of the sac is then drawn inwards and forwards, and the outer and what remains attached of the anterior surface are made free. Finally, the sac is cut off close to the bony canal, and, if there be no close stricture present, the mucous membrane of the duct is curetted with a sharp spoon. The wound is closed by two or three deeply placed

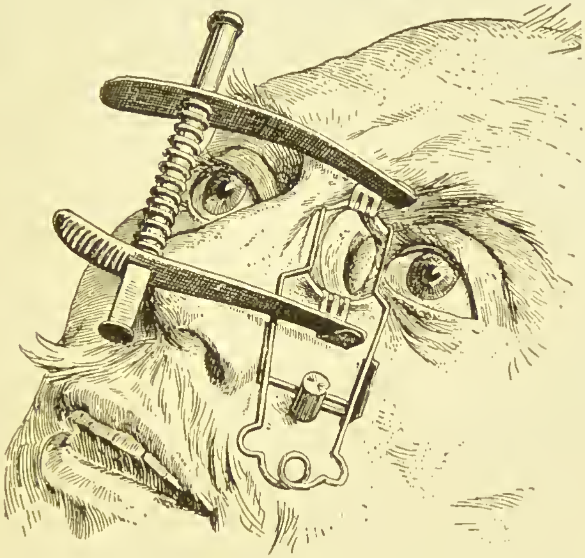

FIG. 148.

utures, special care being taken to secure the palpebral igament to its insertion.

Should the sac be opened during the operation, its total xtirpation will be rendered much more difficult; and f a portion of the sac be left behind, the object of the peration is likely to be frustrated by a return of suppuraion. If the sac be not got out in its entirety, the uspicious places must be destroyed by curetting. Where here is a fistula of the sac, or where there has been phlegmonous dacryocystitis, the operation is rendered difficult by reason of adhesions. Some surgeons consider it unnecessary and undesirable to divide the palpebral ligament, because it is likely to lead to some disfigurement, no matter how carefully the sutures may be applied, but this is not our experience. The wound heals rapidly by first intention, leaving a fine cicatrix which causes practically no disfigurement.

After extirpation of the suppurating lacrimal sac, a source of danger to the eye has been removed, and the patient has been relieved of a troublesome and disfiguring complaint. The lacrimation is less after the operation than before it, not, as has been stated, because the lacrimal gland undergoes atrophy, for no such atrophy takes place, but rather owing to elimination of the fifth nerve reflex from the walls of the diseased sac and from the inflamed conjunctiva. Indeed, unless the surface of the eye be exposed to some considerable irritation, *e.g.* cold wind, foreign body, etc., or there be some psychical emotion, the lacrimation is in no way disturbing, notwithstanding the complete closure of the lacrimal passage; and an adequate explanation of this cannot be offered. Should the lacrimation in some instances be troublesome, removal of the palpebral portion of the lacrimal gland is indicated (p. 337). Removal of the orbital portion of the gland is seldom needed, as its functions seem to cease after removal of the palpebral gland, probably owing to closure of its ducts consequent on removal of the latter gland. Yet a retention tumour of the orbital gland does not ensue.

Acute Dacryocystitis (*δακρύω, to weep; κυστίς, a bladder*).—Acute inflammation of the lacrimal sac most usually comes on when chronic lacrimal blennorrhœa is already present. Caries of the nasal bones may cause it, and it occurs idiopathically, probably as the result of exposure to cold.

The region of the lacrimal sac and the surrounding integument become swollen, tense, and red, and these conditions often spread to the lids, giving an appearance which is sometimes mistaken for erysipelas; but the history of the case, showing the previous existence of lacrimal obstruction, etc., will assist the diagnosis. Great pain accompanies the inflammatory process. Gradually the region corresponding to the lacrimal sac becomes the most prominent one of the swelling, and the abscess, pointing there, opens. When the pus has been discharged the inflammation subsides, and the opening through the skin may either close, the parts resuming their normal functions, or the opening may remain as a permanent fistula.

The difference between chronic blennorrhœa of the lacrimal sac and acute dacryocystitis, besides the fact that one is a chronic and the other an acute inflammatory process, is that the former process is confined to the mucous membrane of the sac, while in the latter the submucous tissue is involved, with phlegmonous inflammation as the result.

Treatment.—In the early stages poultices and purgatives should be employed. As soon as palpation of the sac indicates the presence of pus it must be evacuated. This can be effected either through the canaliculus, by opening it up to its entrance into the sac, or by an incision through the integument over the sac. The latter is the better method, as it admits of free access to the interior of the sac. The next day the walls of the sac are to be freely touched with solid mitigated nitrate of silver; or a plug of cotton-wool soaked in a strong solution of nitrate of silver may be inserted into its cavity, and left there for some hours; or various astringent solutions may be injected into the sac. The aim of the treatment, whatever it may be, is to secure a rapid return of the mucous membrane to its normal condition. If stricture of the nasal duct be present, it must be treated *pari passu*. By these means the discharge from the sac is arrested, and the external opening gradually closes.

If a fistula should form, it may be brought to close, in many cases, by simply freeing an existing stricture of the nasal duct; or, it may be necessary to pare its edges, and bring them together by sutures; or, especially if there be a long fistulous passage, the galvano-cautery, in the form of a platinum wire, can be applied with advantage.

***Dacryoadenitis** (*δακρύω, to weep; ἀδήν, a gland*), or **Inflammation of the Lacrimal Gland**.—This is a very rare affection. It occurs in an acute and in a sub-acute form, and is usually symmetrical in each eye. The acute form is characterised by swelling of the upper lid, especially in its outer third, by chemosis, by diminished mobility of the eyeball upwards and outwards, with displacement downwards and inwards, by local pain often radiating into the frontal region, and by pain on pressure over the gland. On pressure too, the tuberous and swollen gland may be felt, unless œdema of the lid should interfere. In the sub-acute form there is no œdema nor chemosis, and little or no pain, and the diagnosis rests on the presence of a hard and lobulated mass under the outer third of the upper lid, which may displace the globe and interfere with its motion upwards and outwards.

Dacryoadenitis occurs in gonorrhœa, even long after the acute stage of the latter is passed, in epidemics of mumps with or without parotitis, in influenza, diphtheria, measles, and scarlatina. In all these instances it must be regarded as the result of toxic absorption, and having lasted from about three to fourteen days it undergoes resolution with complete recovery.

Dacryoadenitis may also be caused, without any conjunctivitis, by direct infection with the staphylococcus, streptococcus, or pneumococcus, each of which have been found in the inflammatory products, and these cases are liable to go on to suppuration, with formation of abscess. They are usually on one side only.

Finally, cases of tubercular dacryoadenitis have been recorded. The direct clinical diagnosis of these cases cannot be made—the suspicion only of their nature, from the presence of tubercular disease in other parts of the system, can be raised.

Treatment.—Treatment of the ordinary toxæmia. Locally hot fomentations relieve pain and promote resolution. When abscess forms, it generally points in the conjunctival fornix, and is to be opened there. Should tubercle be suspected, removal of the entire gland is indicated.

***Tumours of the Lacrimal Gland.**—Tumours of the lacrimal gland are rare. Sarcoma is the most common of the new growths here, with its mixed forms fibro-, myxo-, adeno-, and lympho-sarcoma. Adenoma is also common, and lymphoma, angioma, and some other varieties have been observed. In the beginning, the outer third of the upper lid seems swollen, but palpation shows this to be caused by a tumour behind the lid, not in it, and also that the tumour originates in the orbit. Gradually, by pressure of this growing tumour, the eyeball becomes displaced forwards and inwards, and its motions are curtailed in the upward and outward direction. In many instances the growth extends backwards into the orbit behind the globe, and then the direction of the displacement is more markedly forwards. The tumour may become fixed to the orbital margin, or the roof of the orbit may be involved and even perforated, and vision may be affected, if the optic nerve be pressed on.

Treatment.—Extirpation of the growth is indicated. If it come under care at an early stage, it can be reached and effectually removed, either through an incision made through the lid parallel to the outer half of the orbital margin; or, the external commissure having been divided, and the upper lid turned up, through an incision made in the conjunctival fornix. In later stages, especially when the tumour has extended deeply into the orbit, Krönlein's operation (chap. xix.) is indicated.

***Tubercular Tumour of the Lacrimal Gland.**—A few cases of tubercular tumour of the lacrimal gland have been recorded. The tumour presented itself as a very hard mass, about the size of an almond, freely movable under the skin, and unattended by pain. In some instances the history had extended over several years, and in others has lasted for some months only. In most of the cases there was tubercular disease elsewhere in the system, but in one instance there was none, nor any hereditary disposition to tubercle.

Treatment.—Extirpation of the gland.

***Cysts of the Lacrimal Gland.** These are rare. The most common of them is Dacryops, a term applied to a retention cyst, which occurs almost exclusively in the palpebral portion of the gland, may attain the size of a hazel nut, and appears as a more or less transparent bluish swelling in the outer part of the upper fornix.

Treatment.—Excision of a portion of the outer wall of the cyst.

*** Symmetrical Chronic Swelling of the Lacrimal and Salivary Glands.**—A few cases of this remarkable affection have been observed. In it there is enormous swelling of each lacrimal, parotid, and submaxillary gland, while the sublingual glands, and small salivary glands in the cheek are also swollen, the whole producing a striking alteration in the physiognomy of the patient. In one instance partial removal of the lacrimal gland was performed, but recurrence took place.

***Extirpation of the Lacrimal Gland.**—This operation is performed by making an incision through the integument under the outer third of the orbital margin; the subjacent fascia is dissected up, the gland drawn forward with a hook, and dissected out with a scalpel. Or, if it be considered sufficient to remove the palpebral portion, this can be done from the conjunctival surface, by separating the lids widely at the outer canthus, while the patient looks well down and to the nasal side, when the palpebral gland will become prominent in the upper fornix (Fig. 149), and can be seized and cut out with scissors. This partial removal may be performed for persistent lacrimation when other means fail. As already stated, when a large tumour of the gland is present, Krönlein's operation is often needed. The absence of tears, which follows upon extirpation of the lacrimal gland, is not serious for the eye; for normally the gland secretes very little, unless under the stimulus of a fifth nerve or psychical reflex. Under other conditions, the surface of the eye is kept moist mainly by the conjunctival secretion, which consists not merely of mucus, but of a watery fluid sufficient when there is absolutely no secretion of tears—as in extirpation of the lacrimal gland combined with paralysis of the fifth nerve—to keep the surface of the eye moist.

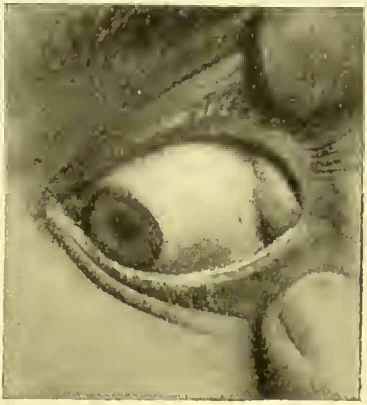

FIG. 149.

CHAPTER X.

DISEASES OF THE SCLEROTIC.

INFLAMMATION of the sclerotic is not a common disease, although the diagnosis 'scleritis' is often made by inexperienced persons, every redness of the white of the eye being taken for inflammation of the sclerotic. Beginners are warned against this error. Iritis, cyclitis, and sometimes conjunctivitis, as well as scleritis, cause redness of the white of the eye.

The diagnosis from conjunctivitis is easily made, by observing whether the conjunctival vessels can be moved over the affected part or not; while in iritis and cyclitis the ciliary injection is confined to the part immediately surrounding the cornea. Moreover, in iritis the appearance of the iris itself is conclusive; and in scleritis, as will be seen just now, the appearances are characteristic.

Scleritis attacks only that part of the sclerotic which is anterior to the equator of the eyeball, and it is either superficial or deep. The superficial form is known as episcleritis. Yet it is not always possible to distinguish between these two forms in a given case, as the appearances in the early stages are very similar. They are probably only different degrees of the same disease. But the necessity of admitting the existence of two forms depends upon the different course they each take; the superficial form being a relatively harmless disease, while the deep form entails serious consequences.

Episcleritis.—Of this two kinds are recognised:—
1. Periodic Transient Episcleritis (Fuchs), or Hot Eye

(Hutchinson). It is characterised by frequently recurring attacks of inflammation of the episcleral connective tissue, giving rise to a vascular injection of a violet hue, but without any catarrhal or other secretion, or any hard infiltration, as in episcleritis of the usual type. It rarely attacks the whole sclerotic at one time, but is commonly confined to a quadrant or more, and wanders from one place to another. When the attack subsides there is no stain left. The attack may be confined to one eye, or it may be in both, or it may affect sometimes one eye and sometimes the other. Pain, watering of the eye, and photophobia are present in varying degrees. Sometimes there is swelling of the eyelids. Occasionally the iris and ciliary body become inflamed, and also the cellular tissue of the orbit, with resulting exophthalmos. The attacks last from one or two days to several weeks, and may recur once or twice a year and at intervals of only two or three weeks. Patients are usually liable to the disease for several years of their life. It attacks adults of middle age for the most part. Hutchinson assigns gout as the cause; but Fuchs has not been able to find any symptoms of that diathesis in his patients. Rheumatism and malaria seem sometimes to produce it, and some observers hold that episcleritis and scleritis are frequently of tubercular or of syphilitic origin.

Treatment.—The long continuance of most of the cases shows that treatment has but little influence over the disease. Quinine and salicylate of soda internally are the remedies likely to be of most use, with local warm fomentations, dionine, and a protection bandage during an attack.

2. Episcleritis, of the usual type. This appears as a circumscribed purplish, rather than red, spot, close to, or 2 to 3 mm. removed from, the corneal margin. It is often unattended by pain, unless when the eye is exposed to irritating causes, and need not be elevated above the level of the sclerotic; but in severe

cases there is a decided node at the affected place, with more or less pronounced pain, which is increased on pressure. All the symptoms disappear in the course of a few weeks, and reappear at an adjoining place; and in this way, in time, the whole circumference of the sclerotic will have been attacked. The duration of the affection is usually long; and, in those instances where the entire sclerotic becomes affected by degrees, the process may last for years, on and off. Both eyes are often affected. The disease is liable to leave behind it a dusky discoloration of the sclerotic where each node was seated, but otherwise no harm to the eye ensues. But the patient should be made acquainted with the tedious nature of the affection. Very mild attacks of episcleritis will be met with, which pass away in a few days, and do not recur.

Causes.—The affection is often of gouty or rheumatic origin. It occurs sometimes in persons of tubercular or syphilitic constitution; and it is more frequent in senior adults than in children or young people; and more commonly attacks women than men.

Treatment.—No irritant should be applied to the eye. Local treatment should be confined to protection with dressing and bandages, warm fomentations, and dionine. In addition to these, massage should be used, if there be not too great tenderness on pressure. Leeching at the external canthus is of use when the pain is severe. As regards internal remedies, where a syphilitic taint is present, mercury should be employed; if struma, cod-liver oil, maltine, etc.; or if, as is most frequently the case, rheumatism be the source of the evil, large doses of salicylate of sodium (say 20 grains four times a day) will often be found to act well. Salicylate of lithium is recommended in preference to the sodium salt by some. Iodide of potassium in large doses (20 grains four times a day, or oftener) is a useful remedy in some cases of this obstinate disease.

Deep Scleritis.—Here the whole of that part of the sclerotic which forms the front of the eye is more likely to be affected at once than in the milder forms; although cases often enough occur where only an isolated node is present at one time.'

It is the progress of the case alone which can render the diagnosis between this and the milder forms certain, and hence the importance of a guarded prognosis in the early stages of every case of scleritis. In this deep form changes —thinning and softening—of the scleral tissue take place, which render the latter less resistant, and consequently expose it to distension by even the normal intraocular tension. The result of this is a bulging (staphyloma) of the anterior part of the eyeball. This bulging in itself produces myopia, and has a deleterious effect upon the sight; but, at a later period, vision is often wholly destroyed by secondary glaucoma. It may happen, that the thinning, etc., of the sclerotic affects only a portion, and not the whole, of its anterior surface; and in such a case the resulting staphyloma will be confined to that part of the sclerotic. A staphyloma, whether total or partial, presents a bluish-grey appearance, due to the uveal tract shining through the thinned sclerotic.

Either with or without such staphylomatous changes, sclerotising opacity of the cornea may come on, and iritis, chorioiditis, and opacity of the vitreous humour are not uncommon complications, especially in strumous subjects. Both eyes are usually affected.

Causes.—Young adults are the most common subjects of deep scleritis, and it attacks females more often than males. Syphilis, congenital or acquired, rheumatism, gout, tubercle, and disturbances of menstruation are the most common assignable causes.

Treatment.—There are few diseases less amenable to treatment. When any of the above causes can be assumed to be present, the suitable remedies are of course indicated.

Besides this, a bandage when only one eye is affected, warm fomentations, dionine, dry cupping on the temple, or the artificial leech, complete rest of the eyes, and protection with dark glasses are to be recommended.

When all acute inflammation has passed away, an iridectomy is sometimes indicated—either for optical purposes, when the pupil is obstructed by corneal opacity, or for the purpose of reducing glaucomatous tension, or of diminishing a staphyloma.

***Syphilitic Gumma of the Sclerotic.**—This is rare. The diagnosis depends to a great extent on the history and co-existing signs of syphilis. The appearance usually presented is that of one or more rounded tumours of sizes which may vary from that of a pea to that of a hazel nut. These tumours are covered with a highly injected conjunctiva, through which the yellowish colour of the gummata shines. They are seated close to the corneal margin—and, consequently, give rise to opacity in the neighbouring sector of the latter—but may extend as far as the equator, or even farther back. As a rule there is much pain in the eye and head. Iritis, retinitis, and vitreous opacities may form complications. In advanced stages the sclerotic may be perforated, or become staphylomatous, and the gumma may extend to the interior of the eye, producing detachment of the retina, and atrophy of the eyeball.

Treatment.—In the early stages an energetic mercurial treatment is capable of producing such perfect cures that not even a slight discoloration of the sclerotic remains.

***Tubercle of the Sclerotic.**—Apart from those cases of episcleritis and scleritis which may be due to tubercle, the only form in which primary tubercle of the sclerotic occurs is as a small tubercular abscess or cyst, and such cases are rare. In one which occurred at the Victoria Hospital the small subconjunctival elevation (Fig. 150) was situated about 4 mm. from the lower margin of the cornea. It was 4 mm. broad at its base, and towards its apex was of a pearly white colour, while the vessels of the conjunctiva covering it were much injected. The abscess was incised, and its cavity in the substance of the sclerotic thoroughly curetted, after which a rapid cure took place. Examination of the contents of the abscess demonstrated the presence of the tubercle bacillus.

In the majority of cases of tubercle of the sclerotic, the disease is an extension from the root of the iris, or from the ciliary body, where it has had its primary seat. Gradually the sclerotic becomes thinned by the tubercular disease, staphyloma forms, and finally rupture may take place. In these cases, if the disease be not too advanced, treatment with tuberculin T. R. may be tried, but in later stages excision of the eyeball is indicated.

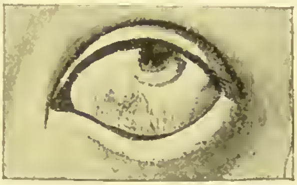

FIG. 150.

***Tumours of the Sclerotic,** as primary growths, are exceedingly rare; but fibroma, sarcoma, and osteoma have been so observed.

***Pigment Spots** of a yellowish-brown colour are often seen in the sclerotic close to the corneal margin. They are congenital, and of no importance. Occasionally a black pigmented patch may be associated with pigmented sarcoma of the ciliary region.

Injuries of the Sclerotic.—Ruptures and perforating wounds are those which have to be considered. Mere losses of substance may be said not to occur.

The primary danger of a rupture or perforating wound of the sclerotic—apart from the loss of the contents of the eyeball, which is often associated with it—consists in the possibility of infecting organisms being introduced into the interior of the eye, and there setting up serious inflammatory reaction.

Ruptures are caused by blows on the eye, and are often indirect; thus, if the blow be received below the cornea, the rupture may take place above the cornea. A common cause of sclerotic ruptures amongst the agricultural population is a blow from a cow's horn, while the animal is being tied up or fed in the byre. The lower and outer part of the orbit is the least prominent, and therefore the eye is least protected here, and hence it is commonly driven upwards and inwards by the blow, and the sclerotic usually ruptures from 2 mm. to 5 mm. from the upper and inner margin of the cornea, and concentrically with the latter. Often the conjunctiva is not ruptured, but bridges over the opening in the sclerotic. Some of the contents of the eyeball may have been forced out through the rupture—*e.g.*, portions of the uvea, iris, and ciliary body, the vitreous, and the lens; and it is sometimes difficult at first to ascertain the exact state of affairs, by reason of extravasated blood in the anterior chamber, under the conjunctiva, and in the tissues of the eyelids. When the conjunctiva is not ruptured, it is often advisable to confine treatment to the application of a bandage, as the covering conjunctiva acts as a protection against infection of the wound. Where serious damage has not been done to the retina, fair or even good vision may be regained in many of these cases, which at first sight seem almost hopeless; and, should perception of light be present, one may reasonably conclude that the retina is not detached. When the lens has been dislocated under the conjunctiva,—from whence it can be removed, after the sclerotic opening has closed,—the patient will of course require a glass as after cataract operation, to give him the best vision.

A large and gaping perforating wound is easily recognised. A portion of the chorioid, ciliary body, or iris, according to the position of the wound, probably lies in it, or part of the vitreous humour may be found in it; while the vitreous humour, as seen through the pupil, will be full of blood (hæmophthalmos), and blood may be present in the anterior chamber (hyphæma, *ὑπό, under; αἷμα, blood*), especially if the wound be far forwards. Small wounds may be concealed by sub-conjunctival hæmorrhage, and here reduced tension of the eyeball is sometimes a valuable diagnostic sign.

A clean-cut perforating wound of the sclerotic may heal without inflammatory reaction, even when portions of the uveal tract or vitreous humour are prolapsed into it, these prolapsed parts becoming incarcerated in the cicatrix.

When inflammatory reaction follows upon one of these injuries it may be either of the purulent or plastic form. In the former case all the contents of the eyeball take part in the suppuration, and we term it panophthalmitis, phthisis bulbi being its ultimate result. In the plastic form, the iris and ciliary body alone are implicated, and sight is slowly lost; the eye here, too, becoming phthisical. Of the two, the latter process is the more serious, as it is prone to give rise to sympathetic ophthalmitis—a danger which is not associated with the eye lost through panophthalmitis.

Where the wound has been produced by a small foreign body, which has remained in the interior of the eye, the position is much more serious, and this subject will be discussed in chap. xv.

Treatment.—In cases where the wound is small (say less than 3 mm.), no suture need be used: a carefully applied dressing and bandage will be sufficient to promote the natural tendency to healing. But, where the wound is large and gaping, any prolapsed chorioid, etc., must be freely irrigated with sublimate lotion, 1 in 5000, and completely reduced—or if the prolapsed parts, or portion of them, cannot be reduced, they must be abscised—and the margins of the wound drawn together by a few points of fine silk suture passed through part of the thickness of the sclerotic; or, the sutures may be passed through the conjunctiva at some distance from the edges of the wound, the traction on the conjunctiva being often sufficient to close the scleral wound. A bandage is applied to each eye, and the patient is confined to bed. But, if the injury be such—very gaping wound, much loss of contents of the eyeball, or extensive intraocular hæmorrhage—as to render restoration of useful sight, or at least retention of the shape of the eyeball, beyond reasonable hope, it is wiser to remove the eyeball at once, rather than to run the risk of sympathetic ophthalmitis without compensating advantage.

CHAPTER XI.

DISEASES OF THE UVEAL TRACT.

INFLAMMATIONS.

THE iris, ciliary body, and chorioid[1] together form the uveal tract. If it be remembered that they closely resemble each other histologically, that their blood supply is identical, and that they form with each other a continuous membrane, it is a matter of surprise that any one of these three divisions of the uveal tract can undergo inflammation while the others remain healthy. Yet this is by no means uncommonly the case. But it is more common for at least two of them, and especially the iris and ciliary body (*irido-cyclitis*), to be simultaneously inflamed; and the entire uveal tract may be affected at one time (*irido-chorioiditis*—by which term it is implied, not only that the iris and the chorioid are diseased, but also the intervening portion of the tract, the ciliary body). If all three portions be affected, one of them may be much more affected than either of the others. Or, commencing in one portion, the inflammatory process often spreads to one or both of the other portions.

Clinically we cannot always know whether only one or more than one division of the uveal tract is in a state of inflammation. This uncertainty of diagnosis is particularly liable to arise when there is severe acute iritis; for then the symptoms present might all be derived from the inflammation of the iris alone, while the contracted and obscured pupil, opacity in the aqueous humour and cornea, and irritability of the eye, render impossible a diagnosis of chorioiditis by the ophthalmoscope; and, whether in health or disease, the position of the ciliary body puts it always out of reach of ophthalmoscopic examination. Yet it may be taken for granted, that in every rather severe case of iritis, particularly in those of syphilitic origin, more or less cyclitis is also present; while a deep anterior chamber, diminished tension, tenderness on pressure, or punctate deposits on the posterior surface of the cornea increase the suspicion. In most cases of very slight iritis there is probably no cyclitis.

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[1] χόριον, *the chorion;* hence chorioid, *like the chorion.*

It is only after the acute inflammatory symptoms have subsided, and the pupil has become clear, that disseminated changes in the chorioid, opacities in the vitreous humour, and even retinitis and optic neuritis, which may lead to optic atrophy, can be discovered, with their corresponding depreciation of vision.

It is convenient, in a systematic consideration of inflammation of the uveal tract, to discuss it under the separate headings of iritis, cyclitis, and chorioiditis.

Inflammation of the Iris. Iritis.—Iritis is acute or chronic, the acute cases forming the large majority. Again, iritis is primary or secondary. In primary iritis, the iris is the original seat of the disease, and is not a result of some other diseased process in the eye. In secondary iritis, the inflammation has been caused by disease of the cornea or sclerotic, or is the result of swelling of an injured lens, the presence of an intraocular tumour, etc.

Acute Iritis.—*The Objective Signs of Acute Primary Iritis*, more or less marked according to the severity of the case, are:—(*a*) loss of lustre and of distinctness of pattern of the iris; (*b*) change in colour of the iris; (*c*) functional disturbances (impaired mobility) of the iris; (*d*) contraction of the pupil; (*e*) circumcorneal injection of the ciliary vessels.

(*a*) The loss of lustre and of distinctness of pattern is due to an alteration in the endothelium, which covers the surface of the iris, to the presence of lymph in the iris and on it, and to cloudiness of the aqueous humour through which it is seen, caused by inflammatory products held in suspension, and often, also, to some cloudiness of the cornea. (*b*) The change in colour is due to hyperæmia of the iris, as well as to the presence of the inflammatory products; a blue iris becomes greenish, a brown iris yellowish. (*c*) The impaired mobility, and the (*d*) contracted pupil, are due to hyperæmia, to spasm of the sphincter iridis, and to posterior synechiæ. (*e*) The circumcorneal, or ciliary, injection is due to engorgement of the episcleral branches of the anterior ciliary arteries which supply the iris.

Exudation of inflammatory products is present, in greater or less degree, on either surface of the iris, and in its stroma; in the pupil, or rather on the anterior capsule of the lens in the pupillary area of the latter, and—when as so often happens, cyclitis is associated with iritis—in the aqueous humour, and on the posterior surface of the cornea. As a consequence of the exudation in and on the iris, in addition to change in colour, and loss of pattern, the iris is often swollen.

Posterior synechiæ[1]—*i.e.* adhesions between the iris and the anterior capsule of the lens—occur as a result of inflammatory exudation on the posterior surface of the iris, or on its pupillary margin. The presence of posterior synechiæ is ascertained by observing the play of the pupil when the eye is placed alternately in strong light and in deep shadow, or by observing the effect of a drop of atropine solution on the pupil, the latter dilating only at those places where there are no synechiæ. The pupillary margin may be adherent at one or two points only, or there may be broad synechiæ occupying at least a fourth, or a third, or more of the margin of the pupil, or there may be both small and broad synechiæ present, or, finally, the entire margin of the pupil may be adherent. If the entire pupillary margin have become adherent, the condition is termed complete posterior synechiæ (or circular posterior synechia, ring synechiæ, or exclusion of the pupil); and in such cases, especially if of some standing, atropine has no effect on the pupil. When complete posterior synechia has developed, the iris after a time becomes bulged forwards like the sail of a ship in the wind, by reason of accumulation behind it of aqueous humour, which now cannot escape into the anterior chamber, and this condition is known as iris bombé: it is very liable to cause high tension of the eye (Secondary Glaucoma).

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[1] συνέχειν, *to bind together.*

If the area of the pupil be filled with exudation—lying on the anterior capsule of the lens—circular synechia being usually also present, the condition is known as occlusion of the pupil.

Total posterior synechia is that condition in which the whole posterior surface of the iris is adherent to the capsule of the lens. It is rarely the result of ordinary iritis, but is seen frequently in sympathetic ophthalmitis (p. 380).

Exudation of inflammatory products into the anterior chamber causes turbidity of the aqueous humour, and sometimes these products sink to the bottom of the chamber and form a pseudo-hypopion. In some rare cases, the exudation in the anterior chamber takes the form of a jelly-like mass, which may resemble a dislocated crystalline lens. On the posterior surface of the cornea, in some instances, exudation is seen as punctate deposits (so-called keratitis punctata), and these, and turbidity of the aqueous humour, indicate that the ciliary processes are involved in the inflammation.

The Subjective Symptoms of Acute Primary Iritis are:—

(*a*) pain, (*b*) lacrimation and photophobia, (*c*) and dimness of vision. (*a*) The pain is due to irritation of the ciliary nerves in the inflamed part. Yet this pain is not always so much in the eye itself, as in the brow over it, in the corresponding side of the nose, and in the malar bone, and may extend to the whole side of the head. It varies in its intensity and is often more severe at night. Some forms of iritis are usually attended by much pain, while others are free from it. (*b*) The lacrimation and photophobia are reflex effects from irritation of the fifth nerve, they are often absent, and are rarely present to such a degree as in some corneal affections. (*c*) The dimness of vision is due to one or other or to all of the following :—turbidity of the aqueous humour, punctate deposits on the posterior surface of the cornea, exudation of lymph on the pupillary area of the anterior capsule of the lens, opacities in the vitreous humour.

A grave mistake into which beginners often fall is to take a case of iritis to be one of conjunctivitis or scleritis (see pp. 132 and 338), the "redness of the white of the eye" being that which misleads. The appearance of the iris itself—normal, or exhibiting the signs of iritis—will chiefly assist in the diagnosis. Moreover, the pain in iritis is of neuralgic character, but in conjunctivitis, if there be any pain, it is similar to that caused by a foreign body in the conjunctival sac. In iritis there is no discharge, while in conjunctivitis the eyelids are gummed in the morning by muco-purulent secretion. The vascular injection in iritis is of the pericorneal ciliary vessels, but in conjunctivitis of the conjunctival vessels. In iritis, however, it often happens that there is conjunctival as well as ciliary injection. But, as stated, in the diagnosis of iritis, the appearance of the iris itself is the most valuable guide. Look at the iris. If the opposite eye be healthy, compare the iris in the affected eye with that in the healthy eye. These latter are the most important precepts in the diagnosis of iritis.

Etiology of Acute Primary Iritis.—By far the most common cause of acute primary iritis is syphilis, probably 50 per cent. of the cases being due to it. Other causes are tubercle, rheumatism, gonorrhœa, diabetes, enteric fever, pneumonia, influenza.

Syphilitic Iritis.—It is usually in the secondary stage of acquired syphilis, along with, or following on, the papular skin eruption, that one sees iritis; and, in the majority of cases, there is no characteristic appearance to indicate its specific nature, this diagnosis depending upon the general history, or on the presence of other signs of syphilis. The plastic inflammatory exudation is present mainly on the surface of the iris, and along the pupillary margin, and often also in the pupil. The loss of lustre and of distinctness of pattern are well marked, and there is considerable change in colour. Posterior synechiæ always form, and it is occasionally in these cases, that the gelatinous exudation in the anterior chambers mentioned above is seen. The circumcorneal injection is generally well marked, sometimes causing elevation of the limbus of the conjunctiva, and even general, although slight, chemosis. The degree of irritation (pain, photophobia, and lacrimation) varies considerably, and is often slight, even where the appearances in the iris are well marked.

Late in the secondary stage of syphilis, or within a year or so after the primary infection, a form of iritis may occur which can be recognised as syphilitic. It is characterised by the formation of circumscribed nodules, or small condylomata, of a yellowish-red colour, the rest of the iris being apparently intact. These nodules vary in size from that of a hemp-seed to that of a small pea, and are situated usually at the pupillary margin, occasionally at the periphery of the iris, and very rarely in the body of the iris. There may be but one nodule present, and there are seldom more than three or four. This form is not common.

Occasionally iritis occurs in the tertiary stage of syphilis, and then sometimes with the formation of inflammatory tumours in the iris, which are to be regarded as gummata.

In inherited syphilis, iritis does sometimes occur without interstitial keratitis (see p. 243), but is more frequently seen in conjunction with the latter. Childhood and youth are the periods of life in which it is observed.

Tubercular Iritis.—Next to syphilis, tubercle is probably the most common cause of iritis. Tubercle occurs in the iris in three forms; of these, one, the conglomerate or solitary tubercle of the iris, will be described under the heading of New Growths of the Iris (p. 400). It is not usually associated with iritis. The other forms are properly regarded as tubercular iritis. They are:—

a. Very fine miliary nodules which occur in the iris, chiefly at the angle of the anterior chamber, or near the pupillary margin, where they give rise to posterior synechiæ. They are of a yellowish-grey colour, or, by reason of vessels which may form in them, they may be reddish, or cinnamon coloured. There is some iritis, and often, also, punctate deposits on the back of the cornea indicating engagement of the ciliary body. The process runs a sluggish course, and is not painful; the nodules increase in size slowly, cease growth, become smaller, and finally disappear. This form of tubercular iritis has been termed by Leber attenuated tuberculosis of the iris, and its prognosis is favourable, although some derangement of sight may remain as a result of the iritis. The disease is often binocular.

b. The second, and more common, form of disseminated tuberculosis of the iris is also associated with iritis, accompanied with much ciliary injection. But in this form, along with small nodules there are some of larger size—so large, sometimes, as to touch the back of the cornea. They are of a pale buff colour, and may be scattered over the whole iris, although their seat of election—a rather important point for the diagnosis—is the angle of the anterior chamber. This form is frequently, and in our experience at the Victoria Hospital commonly, associated with tubercular disease of the true cornea (tubercular kerato-iritis), which is manifested by a diffuse haze in the deep layers of the cornea, and by the presence, in the same layers, of scattered small and large greyish-yellow tubercular infiltrations, each of them surrounded by a less intense halo. A vascular network, derived from the deep marginal vessels, forms about these corneal infiltrations. Punctate deposits are present on the back of the cornea, and the aqueous humour may be hazy, and if the vitreous humour can be examined, it, too, may be found more or less opaque. This form usually goes on to complete loss of sight if untreated. At a late period, the growth of tubercle ceases, and the shape of the eyeball, with more or less opaque cornea, may be retained, or caseation followed by phthisis bulbi may result. One or both eyes may be attacked. Pain is not a prominent symptom—in many cases there is none.

The diagnosis of tuberculosis of the iris cannot be made off-hand from the presence of nodules in the iris, as nodules occur in other forms of iritis, notably in syphilitic iritis. The syphilitic condyloma is of a yellowish-red, while the tubercular nodule is of a greyish-red or of a buff colour, and often presents a somewhat translucent appearance. Those cases of nodular iritis which are accompanied by infiltrations in the deep layers of the cornea, as above described, can be regarded with great certainty as tubercular. But the history of the patient—exclusion of syphilis acquired or congenital—his present state as regards tubercle elsewhere in the system, and the family history as to tubercle must be investigated. As tubercle of the iris commonly occurs in childhood or in early youth, the exclusion of acquired syphilis is not often difficult, and the presence or absence of the stigmata of congenital syphilis decides the diagnosis in that respect. In leucœmia, and in pseudoleucœmia, iritis with formation of nodules occurs, and in ophthalmia nodosa (p. 176).

Signs of former or existing tubercular disease elsewhere in the body are obviously of great value for the diagnosis, for intra-ocular tuberculosis is now held to be always a secondary or metastatic condition, the primary focus being elsewhere in the system. Should no such focus be found, it must be remembered that it is possible for a small tubercular deposit to be present in the body, which may cause no symptom, and which may escape detection by physical examination; in short, intra-ocular tuberculosis, although not the primary focus, may be the first indication of tubercular infection.

The miscroscopic examination of a portion of the iris removed by iridectomy is conclusive for the diagnosis if tubercle bacilli can be found in it, but this is rarely so. An inoculation experiment, by the insertion of a portion of the iris into the anterior chamber of a rabbit's eye, gives a more certain result. Neither of these measures, however. is admissible, as iridectomy is liable to cause the iritis to take on renewed activity.

Gourfein has proposed, and successfully practised, drawing off the aqueous humour from the tuberculous eye with a fine hypodermic syringe, and injection of it into the anterior chamber of a rabbit's eye, where it gives rise to tubercular iritis. This proceeding is harmless.

Finally, for diagnostic purposes a hypodermic injection of tuberculin may be used. Of the old tuberculin a dose of 1 m.gr. of the dry substance is injected. If the disease be tubercular, a sudden rise of temperature takes places, and as rapidly subsides; and occasionally there is a passing local reaction in the eye.

Rheumatic Iritis is usually of the form which is common in the early secondary stage of syphilis (see above), but accompanied by circumcorneal injection, which is great in proportion to the other signs of iris present. The pain is often peculiarly severe, and again the attack may be painless. Iritis is not found in association with acute rheumatic arthritis, but rather with the sub-acute articular rheumatism which attacks now one joint and again another through several months of the year, in the winter and spring. Rheumatic iritis is very liable to recur.

Gonorrhœal Iritis is also of this form, but punctate deposits on the posterior surface of the cornea are more common in it. It does not attend on, nor immediately follow, a gonorrhœa; but an attack of gonorrhœal arthritis, usually of the knees, always intervenes. It is not very common.

Chronic Iritis.—Practically the only *objective sign* of a slight case of chronic iritis is posterior synechiæ with, it may be, some slight pupillary exudation. Or, in addition to posterior synechiæ, there may be punctate deposits. Or, the latter may be present without synechiæ, when the case is to be regarded rather as chronic cyclitis. Chronic iritis with punctate deposits used to be known as serous iritis, a term now abandoned. In the severer cases, the stroma of the iris is distinctly altered as regards colour and pattern, there are abundant deposits on the back of the cornea, and opacities in the vitreous humour. There is no pericorneal injection in chronic iritis, or, at most, it is slight, occasional, and ephemeral.

The only *subjective symptom* in chronic iritis is defective vision, and this it is which brings the patient for advice. There is little or no pain, photophobia, or lacrimation. On examination signs of iritis are found, and inquiry elicits the fact that, except for gradual failure of sight, the patient has had little trouble beyond an occasional "cold" in the eye—*i.e.* slight ciliary injection—which lasted a few hours, or a day or so at a time in the course of preceding years.

The slighter cases of this affection which are confined to the iris, and do not run a long course, may not cause serious loss of sight. The more severe cases, accompanied by cyclitis and punctate deposits, are liable to be complicated with high tension (secondary glaucoma), owing to blocking of the angle of the anterior chamber with exudation, which seriously endangers vision. In the severest cases the whole uveal tract is involved (chronic irido-chorioiditis) and the exudation of inflammatory products is very great, with the following results—marked punctate deposits, giving rise to parenchymatous opacity of the cornea, turbid aqueous, atrophy of the iris, posterior synechiæ going on to exclusion of the pupil, often occlusion of the pupil, iris bombé, opacity of the vitreous humour, cataract, atrophy of the chorioid and retina, high tension owing to iris bombé, absolute blindness, staphyloma of the globe—or in the last stages the eye may become phthisical instead of staphylomatous. In some few cases iris bombé may not come on, and complete blindness may not result, rendering the prospect of a cataract extraction fairly good.

Chronic iritis frequently occurs, or rather commences, in youth, and is more common amongst females than males. The severe cases may continue intermittently for many years before complete blindness is reached. It is often impossible to assign a cause for the disease. The patients are usually neither syphilitic nor tuberculous. They are sometimes delicate and ill-nourished, and the view is held that many cases are due to auto-intoxication from the gastro-intestinal tract.

Treatment of Acute Primary Iritis.—A mydriatic (see table, p. 420) is in all cases the most important means. Most commonly a solution of atropine (Atrop. sulph. gr. iv, Aq. dest. ℥j) is used as eye-drops. An atom of sulphate of atropine in substance, placed in the conjunctival sac, gives a very active reaction. It is also used in the form of ointment (Atrop. sulph. gr. iv, vaselin ℥j), and gelatine discs containing atropine are manufactured. By paralysing the sphincter iridis, atropine provides rest for the inflamed iris; and, if adhesions have already formed, the dilatation of the pupil may break them down, while if none be as yet present, the dilatation will greatly aid in preventing their formation. Again, owing to diminished volume of the iris, its vessels contain less blood, and the hyperæmia of the inflamed part is reduced. Yet in cases of irido-cyclitis, where the cyclitis is the prominent factor, atropine does not always promote the cure, for by depleting the vessels of the iris it engorges those of the ciliary body. To produce a maximum effect on the pupil, where it is desired to break down adhesions, six drops of the atropine solution should be instilled into the eye, with an interval of from five to ten minutes between each; and in this way the atropine from each drop has time to make its way into the anterior chamber, and finally the accumulated effect of all six is obtained. More than one drop can hardly be retained in the conjunctival sac at a time. The use of cocaine (2 per cent.) along with atropine ensures a maximum dilatation. A drop of the atropine solution into the eye from once or twice to four times a day is required, in order to maintain the desired dilatation of the pupil *ad maximum*, in a severe case.

Some individuals are peculiarly susceptible to atropine poisoning, of which the symptoms are:—dryness of the throat, fever, fulness in the head, headache, delirium, coma. The antidote is morphia, of which $\frac{1}{4}$ grain used hypodermically neutralises $\frac{1}{30}$ grain of atropine in the system. Atropine poisoning can occur by the introduction of the solution into the stomach through the lacrimal canaliculi, nose, and fauces; and to prevent this the finger of the patient may be placed in the inner canthus, so as to occlude both canaliculi during, and for some moments after, the introduction of the drop into the eye.

After use of atropine in some persons the skin of the lower eyelid, or of both eyelids, becomes eczematous, red, swollen, and painful, from infiltration with the drug; and in other cases after long use follicular conjunctivitis is induced. If these complications occur, sol. extr. belladonnæ (gr. viij ad ℥j) should be substituted for atropine, and suitable remedies used for skin (p. 276) or conjunctiva.

In old people tenesmus and retention of urine sometimes result from use of atropine.

Atropine, while it is so useful a means in the treatment of inflammations of the iris, ciliary body, and cornea, is of no benefit in many other diseases of the eye, and is positively harmful in some of them. It is necessary to make this statement very explicitly, for many medical men, who have not devoted attention to the subject of eye-disease, include atropine in every eye-lotion they prescribe. If the disease prescribed for be conjunctivitis, as it very often is, the atropine is calculated rather to increase than to relieve the conjunctival affection; while, if the patient be advanced in life, there is always the danger that a tendency to glaucoma may be present, and in such a case the dilatation of the pupil caused by the atropine will be sufficient to bring on an attack of acute glaucoma. It falls to the lot of most ophthalmic surgeons to be called, at one time or another, to a case of acute glaucoma brought on by the use of atropine in this thoughtless manner.

Dark protection spectacles should be worn by patients suffering from iritis; and in severe cases, especially in cold weather, a bandage ought to be worn, and the patients should be confined to a dark room, and even to bed.

Hot fomentations—for twenty minutes every two hours—are of benefit in all forms of iritis, and relieve pain. Dionine is useful also in relieving pain, and seems to promote the cure. If the pain be severe at night a hypodermic injection of morphia may be given. If there be much irritation, pericorneal injection, or chemosis, leeching at the external canthus over the orbital margin is of use. Occasional gentle purgatives are desirable. Blistering on the temples, or behind the ear, has been a favourite item in the treatment of iritis. It adds to the annoyance of the patient, but as a remedy is of no value.

In addition to the foregoing measures which are applicable in all cases, the special etiological moment must be considered in the treatment of each case, as follows:—

Treatment of Syphilitic Iritis.—As it is important to obtain rapid absorption of the inflammatory products so abundantly thrown out, and which would soon cause extensive damage to sight, the system should be put under the influence of mercury as quickly as possible, by the use of mercurial inunctions, or by small doses of calomel internally, or by intramuscular injections, 1 grain of metallic mercury being injected once or twice a week in the form of a cream made with lanolin as recommended by Lambkin. When the acute symptoms have passed away, an after treatment with iodide of potassium should be employed.[1] In iritis due to congenital syphilis, mercury is not generally indicated, but the syrup of the iodide of iron, and a general tonic treatment is preferable. As, in cases of acquired syphilis, there is a marked tendency of iritis to relapse, it is important that, for some weeks after the acute stage has passed, the pupil should be kept under the influence of atropine, the eyes protected with dark glasses, and the internal administration of iodide of potassium continued.

An attack of syphilitic iritis may last from two to eight weeks, and cases which seem to be slight—*i.e.*, where the pupil dilates well and rapidly to atropine, and where but little lymph is thrown out—sometimes cause disappointment by their slow recovery. It is possible that an attack of iritis, if carefully treated from the beginning, may leave the eye in as healthy a condition as before, but it is more common, in spite of every effort, to find isolated posterior synechiæ, or a circular synechia, left behind. The presence of a few isolated synechiæ, if the pupil be clear, is in itself harmless to sight; but, if relapse should take place, and fresh adhesions form, a complete posterior synechia (see p. 350) going on to iris bombé may ultimately be established. Complete posterior synechia may of course result from the first and only attack of iritis.

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[1] Iodide of potassium must not be prescribed in conjunction with treatment by injections of metallic mercury.

In some cases of iritis, the vitreous humour becomes more or less opaque, and this condition does not always disappear as the iritis gets well; indeed, it may not be possible to ascertain its presence until after the inflammatory process in the iris has subsided. In these cases the ciliary body has participated in the inflammation, although there may have been no punctate deposits on the cornea. Again, there may have been some chorioiditis and retinitis during the attack. Great and permanent deterioration of vision may result from such complications; and this emphasises the importance of a cautious prognosis at the commencement.

In complete posterior synechia, after the acute iritis has subsided, an iridectomy (p. 411) is indicated to restore communication between the posterior and anterior chambers. For the treatment of opacities in the vitreous humour see chap. xv., and of syphilitic chorioiditis see chap. xvi.

Treatment of Tubercular Iritis.—Cases of attenuated tuberculosis of the iris simply require local treatment with atropine, hot fomentations, and protection spectacles. In the treatment of the more pronounced form of tubercular iritis, the tubercular infection must be combated, and the chief therapeutic measure which is of value for this purpose is inoculation with the new tuberculin. The method at first used at the Victoria Hospital was that laid down by A. von Hippel, who introduced treatment with tuberculin into ophthalmic practice. It is as follows:—During the entire course of treatment von Hippel recommends the temperature to be taken every two hours. The subcutaneous, or intramuscular, injections are made every second day. They commence with a dose of $\frac{1}{500}$ mg. of the dry substance, and each successive dose is increased by $\frac{1}{500}$ mg. until $\frac{1}{50}$ mg. is reached. Each dose is then increased by $\frac{1}{50}$ mg. until $\frac{10}{50}$ mg. is reached, then by $\frac{5}{50}$ mg. and so on, the highest dose given in any case being 1 mg. But if, after a dose has been given, a rise of temperature of over 38° C. take place, the previous dose is repeated, and a further increase is not made until a general reaction ceases to be caused. In the majority of cases treated, marked improvement became apparent within a few weeks, the nodules in the iris becoming smaller and less vascularised, the deep-seated corneal infiltrations thinner, the punctate deposits fewer, and the eye less irritable and injected, until finally, with continued treatment, all tubercular deposits and infection disappeared, leaving only such permanent damage to the eye and sight—due to corneal changes and pupillary occlusion—as may be proportional to the duration and severity of the disease before treatment took effect. The treatment is a protracted one, as long as six months, possibly, being needed to effect cure in a severe case.

In the light of the investigations of Sir A. E. Wright, we now use doses of only $\frac{1}{1000}$ to $\frac{1}{600}$ mg. of tuberculin T.R., which do not raise the temperature, and the dose is not repeated until the opsonic index shows that the effect of the preceding inoculation is passing off. Valuable adjuncts in the treatment with tuberculin are local hot fomentations, or the Japanese warmer, with the administration internally of citric acid—a decalcifying agent, to reduce the coagulability and viscidity of the blood—cod liver oil, and syrup of the iodide of iron.

On the question as to whether an eye which is disorganised by intraocular tuberculosis beyond hope of recovery should be excised, opinions are divided. Were the eye the primary focus, excision might be indicated in even a less advanced stage. But cases are on record in which, soon after excision of a tubercular eyeball, death from tubercular meningitis, or from acute miliary tuberculosis, took place ; and which were therefore suggestive of dissemination of the tubercle as direct result of the operation. We can offer no experience of our own in this connection, but it would seem that there is a risk in removing the eyeball in these cases. Where excision is not undertaken, extension of the disease to the optic nerve and so to the brain is exceedingly rare.

For Rheumatic Iritis the general treatment is the same—salicylate of soda, aspirin, etc.—which is found useful for rheumatic symptoms in other parts of the body. In Gonorrheal Iritis, too, treatment with salicylate of soda is the most successful.

The treatment of Chronic Iritis, in so far as the general system is concerned, must consist in correcting any derangement of the health which may be present, and particular attention should be given to the functions of the gastro-intestinal tract. Locally sub-conjunctival saline injections (see chap. xv.) frequently render valuable assistance.

Inflammation of the Ciliary Body : Cyclitis.—Cyclitis, as has been stated, attends all cases of severe acute primary iritis, and often many of the slighter cases, whatever be their etiology, as has been demonstrated by pathological examination. Yet very frequently there are no clinical signs of its presence, or they are masked by those of the iritis. The most common clinical sign of cyclitis in these cases is fine punctate deposits—often so fine as to be discernible only with the combined focal method, or with the corneal microscope—on the back of the cornea, with, it may be, slight turbidity of the aqueous humour, and occasionally the formation of a small pseudo-hypopion. The ciliary processes it is which secrete the aqueous humour; and, when they are inflamed, the inflammatory products are liable to pass from them, and to appear in the above forms in the anterior chamber.

Owing to gravitation, the lower quadrant of the cornea is the part on which the punctate deposits are usually precipitated. The part of the cornea which is thus affected is often of a triangular shape, the base of the triangle corresponding with the lower margin of the cornea, the apex being directed towards the centre of the cornea, with the finer dots near the apex. The triangular shape results from the motions of the eyeball. In many cases, however, nearly the whole cornea is more or less affected.

In cases where the punctate corneal deposits continue for a length of time—in consequence of the resulting degeneration of the endothelium on the posterior corneal surface—permanent secondary changes in the true cornea take place, and a consequent triangular opacity at the lower part of the cornea will ever afterwards indicate the nature of the process which has gone before.

Opacities in the vitreous humour—which is also nourished by the ciliary processes—especially in its anterior part, are another frequent result and sign of cyclitis.

But cyclitis is sometimes seen without iritis. Its signs, in a severe acute case, in addition to those above mentioned, are :—Masked circumcorneal injection, pain on pressure of the ciliary region, deep anterior chamber owing to hypersecretion of the aqueous humour, and œdema of the upper lid. The danger of increase of the intra-ocular tension is great, owing to the tendency to blocking of the angle of the anterior chamber with inflammatory exudation. In some cases the inflammatory products are thrown out abundantly behind the iris in the posterior chamber, causing a total posterior synechia (see p. 350) with the result that the posterior chamber becomes completely obliterated; and, consequently, the anterior chamber, especially at its periphery, is made excessively deep, and the pupil dilated. In these cases the intraocular tension is usually reduced. Severe cases of cyclitis, or of irido-cyclitis, when they continue long, very often become complicated with cataract, owing to derangement of the nutrition of the lens. In consequence of shrinking of the vitreous humour, detachment of the retina is another frequent complication of these cases. Finally, shrinking of the globe (phthisis bulbi) is in many instances the ultimate result.

In chronic cyclitis, the circumcorneal injection is slight. The anterior chamber is often at first deeper than normal, owing to hypersecretion of aqueous humour from the ciliary body; there are punctate opacities on the posterior surface of the cornea; and the anterior part of the vitreous humour is filled with fine dust-like opacities. Iritis may come on (chronic irido-cyclitis), and glaucomatous increase of tension owing to blocking of angle of the anterior chamber. Unless increase of tension give rise to it, pain is not often present.

Syphilitic Cyclitis.—Unless when associated with syphilitic iritis, syphilitic cyclitis cannot be recognised as such.

*Syphilitic Gumma of the Ciliary Body.—This is rare, and belongs to the tertiary stage of syphilis, although it is sometimes seen much earlier. It is always preceded by acute irido-cyclitis of the usual plastic type. It appears at first as a small circumscribed nodule with smooth round surface slightly raised over the surface of the sclerotic in the ciliary region. It increases in size sometimes very rapidly—and is then attended by violent iritis and much pain—and again but slowly. It may attain the size of a pea or even of an almond, and may extend some way around the cornea, presenting a reddish, yellowish, or bluish colour. After a time, in the less severe cases, the gumma becomes smaller and disappears, leaving a dark cicatrix in the sclerotic. But in other cases it breaks through the sclerotic, although very rarely through the conjunctiva, by destruction of tissue, and when this has taken place the tumour grows smaller and undergoes absorption, and the eye becomes phthisical. The interval between the appearance of the gumma and completion of the process is from a few days in the very acute cases, to several weeks in the more chronic cases. The gumma may also grow into the anterior chamber, and but rarely into the vitreous humour. The bulbar conjunctiva is hyperæmic and often chemotic. In the cornea there is generally a slight diffuse opacity with stippling of the epithelium, and there may be posterior punctate deposits. The severe acute cases are accompanied by intense interstitial keratitis, œdema of the upper lid, and violent pain. The mildest cases may end with retention of fair vision, but in most instances serious damage to sight results, while in very many vision is totally lost, and the eye becomes phthisical. In many of the recorded cases the eye was excised in the acute inflammatory stage on account of agonising pain.

*Tubercular Cyclitis.—This is frequently associated with tubercular iritis, although its presence cannot be clinically detected. Yet in some cases the disease in the ciliary body assumes the form of a large nodule, or even a tumour of considerable size—or there may be more than one of these—and causes staphylomatous bulging at the corneo-scleral margin, which may go on to rupture externally.

Treatment of Cyclitis.—This follows very much the lines of the treatment of iritis. Atropin, by paralysing the ciliary muscle, acts favourably on the disease. Yet, if the pupil be dilatable, atropine causes engorgement of the ciliary body by the blood driven out of the iris. Consequently, its effect on the symptoms must be watched, and it may become necessary to dispense with its use, and even for a time to substitute a myotic. Hot fomentations to the eye, and a warm bandage, and, in acute cases, leeching at the external canthus are serviceable. In chronic cyclitis subconjunctival injections of solution of salt are indicated; and, if the intraocular tension become high, paracentesis of the anterior chamber should be performed. In syphilitic gumma of the ciliary body an active mercurial treatment, and in tubercular disease treatment with tuberculin, afford the best prospects of cure.

***Inflammations of the Chorioid.**—There are two chief forms of inflammation of the chorioid (*χόριον, the chorion;* hence chorioid, *like the chorion*), the exudative and the purulent. Of the exudative form, again, there are several kinds, namely, disseminated chorioiditis, central senile guttate chorioiditis, central chorioiditis, and syphilitic chorio-retinitis.

Disseminated Chorioiditis.—The usual Ophthalmoscopic Appearances of this disease consist either in round white spots of different sizes with irregular black margins, or in small spots of pigment, these changes being surrounded by healthy chorioidal tissue; or, there may be few or no white patches, but rather spots of pigment surrounded by a pale margin. The retinal vessels pass over, not under, the patches. The number of these patches or spots varies according to the intensity of the disease. Their position is at first at the periphery of the fundus only, but later on they appear also about the posterior pole of the eye.

These appearances, however, represent a rather late stage of the disease, the early stage not usually coming under observation. It consists in small circumscribed plastic exudations into the tissue of the chorioid, which, if seen with the ophthalmoscope, give the appearance of pale pinkish-yellow or greyish spots behind the retinal vessels. The exudations may undergo absorption, leaving the chorioid in a fairly healthy state; but, more usually, they give rise to atrophic cicatrices, in which the retina becomes adherent, with proliferation of the pigment-epithelium layer in their neighbourhood, and hence the white patches with black margins above described. This is the form of chorioiditis which is often associated with inflammatory processes in the iris or ciliary body, either as a primary or secondary affection. But, again, in many instances the disease does not extend beyond the chorioid.

Sometimes, in addition to the above changes, the pigment-epithelium layer all over the fundus becomes atrophied, exposing to view the vascular network of the chorioid, while here and there small islands of pigment are present.

Opacities in the vitreous humour are sometimes found.

Symptoms.—Diminution in the visual acuity, especially if the macula be involved; there may also be subjective sensations of light or colours, positive scotomata (dark areas visible to the patient), and distortion of objects (metamorphopsia), or alteration in their size (megalopsia and micropsia). Night-blindness is not uncommon.

Causes.—Disseminated chorioiditis is due to acquired syphilis in a considerable number of the cases. And possibly in some it may be tubercular. But in a very large proportion of cases no ascertainable cause exists; and these cases, there is reason to suspect, are congenital, and probably many of them are dependent on an inherited syphilitic taint. In eyes with congenital cataract, patches of chorioiditis are often found.

Prognosis.—Disseminated chorioiditis is always a serious and very chronic disease, fresh spots of exudation making their appearance from time to time, and complete recovery cannot be looked for. The degree of defect of sight it may cause in the early stages depends much on the extent to which the region of the macula lutea has become involved. In advanced cases the optic nerve and retina become atrophied, and still later the lens becomes cataractous.

Treatment.—In fresh cases due to acquired syphilis, a prolonged but mild course of mercurial inunctions is the most suitable measure, to be followed by a lengthened course of treatment with iodide of potassium. Where an inherited syphilitic taint is suspected, iodide of iron or iodide of potassium internally may be of use; while, in the cases due to other causes, small doses of perchloride of mercury may be given; and in all cases, from whatever cause, subconjunctival injections of 4 per cent. solution of common salt are indicated. Dark protection spectacles should be worn, and absolute rest of the eyes from all near work insisted upon, so long as the disease is active.

*Central Senile Guttate Chorioiditis.—Under this name an appearance has been described by Mr. Waren Tay and others, which consists of fine white, pale yellow, or glistening dots, best seen in the upright image, and situated chiefly about the macular region, or between this and the optic papilla. These dots are due to colloid degeneration with chalky formations in the vitreous layer of the chorioid, which give rise to secondary retinal changes. The appearances must not be confounded, as they sometimes have been, with those of retinitis punctata albescens (chap. xvi.), which is an entirely different disease. The functions of the retina usually suffer in a marked manner, so that a partial central scotoma may be produced; but some cases have been observed, in which vision was but little, or not at all, affected.

This disease attacks both eyes, either simultaneously or with an interval, and is most often seen in persons of advanced life, although it is also found in middle age, and even in youth. It should always be looked for in cases of incipient cataract; for when the lental opacity is more advanced it cannot be seen, while functional examination does not then reveal it.

Treatment is of no avail.

*Central Chorioiditis.—This is an exudation at the macula lutea, without any similar disease elsewhere in the fundus. Absolute central scotoma is its prominent symptom, and syphilis its usual cause.

Treatment.—Active mercurialisation; and, where this can be adopted early, the prognosis for recovery of sight is fairly good. Subconjunctival salt injections aid the cure.

Syphilitic Chorioido-Retinitis.—See Syphilitic Retinitis, chap. xvi.

Tubercle of the Chorioid.—See p. 405.

Purulent Chorioiditis.—This consists at first in a purulent extravasation between the chorioid and retina, and into the vitreous humour, recognisable by the yellowish reflection obtained from the interior of the eye on illuminating it. The eyeball may become hard, the pupil dilated, and the anterior chamber shallow. Purulent iritis with hypöpyon soon comes on, and the cornea may also become infiltrated and slough away. There is usually considerable chemosis. The eyeball is pushed forwards by inflammatory œdema of the orbital connective tissue. The eyelids are swollen and congested. There is intense pulsating pain in the eye, and radiating pains through the head; and in this stage all the tissues of the eyeball are engaged in the purulent inflammation, and the condition is termed Panophthalmitis.

Purulent chorioiditis does not reach this latter stage in every case, but may remain confined chiefly to the chorioid, vitreous humour, and iris. The pain in these cases is not severe; and when the affection occurs in children it may be mistaken for glioma of the retina (chap. xvi.); indeed, the name pseudo-glioma has, unfortunately, been given to it. It is distinguished from glioma by the muddy vitreous usually present with it, by the posterior synechiæ, and by the retraction of the periphery of the iris, with bulging forwards of its pupillary part.

Prognosis.—The ultimate result in the vast majority of cases is loss of sight, with phthisis bulbi. The severe cases go on to rupture of the eyeball through the cornea or sclerotic, after which the pain subsides. It would seem from the description of authors who have seen much of epidemic cerebro-spinal meningitis, that a certain number of cases of irido-chorioiditis occurring in the course of that disease do recover with retention of good sight.

The shrunken eyeballs produced by panophthalmitis are not generally painful on pressure. They are not very liable to give rise to sympathetic ophthalmitis, and the latter statement is also true of the acute purulent process itself. It is cases of traumatic plastic irido-chorioiditis which produce sympathetic ophthalmitis.

Causes.—The most common causes of purulent chorioiditis are perforating wounds of the eyeball, whether accidental or operative; foreign bodies piercing and lodging in the eyeball; and purulent keratitis. It may also come on suddenly in eyes which are the subjects of incarceration of the iris in a corneal cicatrix, through infection of the incarcerated iris. Again, it is seen as embolic or metastatic chorioiditis, in connection both with epidemic and sporadic cerebro-spinal meningitis (chap. xx.); in some cases of metria, similarly as purulent retinitis (chap. xvi.); in pyæmia of the ordinary type; and in endocarditis.

In infancy and childhood, besides its occurrence with cerebro-spinal meningitis, it has been known to be caused by, or associated with, inherited syphilis, measles, bronchitis, diarrhœa, hooping-cough, and omphalo-phlebitis; and it is more than probable that, in every idiopathic case, some infective blood-disease is the fundamental cause of the process, although it may not always be possible to determine its existence.

Treatment may be said to be powerless in this disease.

The utmost one can do is to endeavour to diminish the pain in the very severe cases by warm fomentations, poultices containing conium, hypodermic injections of morphia, or, finally, by giving exit to the pus by a free incision in the eyeball, followed by a copious irrigation with weak sublimate lotion, so as to wash out the whole contents of the scleral cavity. Quinine and chlorate of potash are suitable internal remedies.

Enucleation of the eyeball should not be undertaken during purulent chorioiditis in the acute stage, as it is liable to lead to purulent meningitis and death.

SYMPATHETIC OPHTHALMITIS, AND SYMPATHETIC IRRITATION.

Introductory.—By the term Sympathetic Ophthalmitis we understand a general plastic uveitis (plastic inflammation of iris, ciliary body, and chorioid) of one eye, which has been caused by a plastic uveitis of the other eye, the latter condition being most commonly due to a perforating trauma, or other perforation of the eyeball. Or, the sympathetic ophthalmitis occasionally consists in an optic neuritis or chorioiditis.

There are no such diseases as sympathetic cataract, conjunctivitis, detachment of the retina, keratitis, scleritis, etc.

The term 'sympathetic' in this connection is an old one, and probably would not be employed had the disease to be named at the present time.

Sympathetic ophthalmitis is not a fifth-nerve reflex phenomenon. It is, as stated, a uveitis, and often also an optic neuritis, which has arisen by transmission of certain undetermined micro-organisms, from the injured eye, in which uveitis has been set up, to the sympathising eye. No sympathetic uveitis can be developed in the second eye, until after uveitis in the first eye has commenced. A perforating injury of the eyeball, or other perforation, which does not produce uveitis in that eye, does not give rise to sympathetic ophthalmitis in the fellow eye. Yet, traumatic uveitis in the injured eye does not cause sympathetic ophthalmitis in every case.

The eye which has received the perforating injury is spoken of as the exciting eye, and its fellow, which becomes the subject of sympathetic ophthalmitis, as the sympathising eye. The eyes are also spoken of as the injured eye, and the sympathising eye; also as the first eye, and the second eye.[1]

While sympathetic ophthalmitis is not a reflex condition, there is an affection known as sympathetic irritation, which is a true fifth-nerve reflex neurosis. These affections, although sometimes closely associated clinically, are quite distinct from each other.

Before treating of sympathetic ophthalmitis, it will be convenient to state what is necessary concerning sympathetic irritation.

Sympathetic Irritation.—This may be caused by almost anything which produces irritability of the ciliary nerves in the first eye—*e.g.*, foreign bodies on the cornea or under the upper lid, losses of substance of the corneal epithelium, anterior staphyloma, acute glaucoma, iritis, dislocation of the crystalline lens, etc., etc.

Amongst the many causes of sympathetic irritation is an irritable shrunken globe, whether the latter condition be the result of a uveitis from a perforating injury, or of an idiopathic uveitis; and an irritable shrunken globe may give rise to sympathetic irritation in the fellow eye at any time, even after many years. Having remained quiet for so long, the shrunken eye begins to lacrimate, and becomes painful and injected. A fresh injury to the stump may be the cause of this, or it may be ossification of its choroid, and the irritation, whatever its cause, may be transmitted to the sound eye.

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[1] German authors term the injured eye the sympathising eye, and the second eye the sympathised eye.

The most common symptoms of sympathetic irritation of the second eye are: photophobia, lacrimation, vascular injection of the front of the eyeball, and accommodative asthenopia, and, in a well-marked case, these symptoms become intensely distressing to the patient. Neuralgia in the orbit and brow, and retinal asthenopia sometimes occur.

Sympathetic ophthalmitis is also often caused by a shrunken fellow eyeball, in which uveitis, indicated by the presence of irritability, is present (*vide infra*); and of great importance is the question: What relation, if any, has sympathetic irritation to sympathetic ophthalmitis in such cases? Is sympathetic irritation to be regarded as a reliable and essential premonitory symptom of sympathetic ophthalmitis? The answer is in the negative. Sympathetic irritation may last an indefinitely long time, without being followed by sympathetic ophthalmitis. Further, although some sign or signs of sympathetic irritation often do precede the onset of sympathetic ophthalmitis, yet in many cases every such sign is wanting. It is, therefore, in view of the latter fact, wrong to postpone a prophylactic enucleation, until sympathetic irritation shows itself.

Treatment.—When sympathetic irritation is caused by an irritable shrunken globe on the opposite side, it can be immediately relieved by removal of the stump. Rest in a dark room and sedative measures, while they may seem to cure, merely lead to disappointment, owing to the almost certain return of the symptoms, when the eye is brought into use again. Moreover, as sympathetic irritation does often precede sympathetic inflammation, it is wise to enucleate the exciting stump in order to assure the safety of the second eye.

SYMPATHETIC OPHTHALMITIS. **Diagnosis.**—The inflammation of the uveal tract in the sympathising eye has no characteristics which enable us to make the diagnosis 'Sympathetic Ophthalmitis,' for precisely the same plastic or sero-plastic uveitis, as the case may be, is seen under other conditions; nor is the state of the first eye, taken alone, a certain guide. To arrive at a diagnosis, it is necessary to weigh the following data, and to take them collectively into consideration:—

1. The condition of the exciting eye, and the nature of the injury to, or disease of, that eye.
2. The condition of the sympathising eye.
3. The interval that has elapsed between the injury to the exciting eye, and the onset of the uveitis in the sympathising eye.
4. The state of the general system.

1. *The Condition of the Exciting Eye.*—As already stated, perforating injuries, or perforating corneal ulcers, of the first or exciting eye, which are followed by plastic uveitis, are by far the most common causes of sympathetic ophthalmitis. The position of the wound in the eye has no influence in the production of sympathetic ophthalmitis. Uveitis in the injured eye is due to infection of the wound by micro-organisms derived from the foreign body, or instrument, which has caused the wound, but sometimes perhaps from the surface of the eye, or from the atmosphere.

Either a purulent uveitis, or a plastic uveitis, may result from the injury.

Purulent uveitis of a not very pronounced type (purulent infiltration of the vitreous humour, iritis, hypopyon) is very occasionally followed by sympathetic ophthalmitis, but, and it is a remarkable clinical fact, the marked purulent uveitis, which is called panophthalmitis (p. 370), may be said never to give rise to it. It is obviously not a pyogenic micro-organism which causes sympathetic ophthalmitis, for, if it were, the latter would be a purulent process; but it is some specific micro-organism; and it can hardly be doubted that in those rare instances in which sympathetic ophthalmitis has followed on slight purulent uveitis, this specific organism has been present in the injured eye along with the staphylococcus.

If the infection of the injured eye be purulent, the inflammatory reaction in it comes on within the first thirty-six hours after the injury; while the fibrinous or plastic inflammatory reaction, caused by the specific organism, which is so dangerous in relation to sympathetic ophthalmitis, declares itself in the injured eye less quickly and more insidiously.

In the case of the latter infection, the injection and irritation, the immediate results of the injury, disappear in a few days, only soon to return. The pupil then begins to dilate less well to atropine, the tissue of the iris becomes less distinctly seen, some posterior synechiæ form, and some opacities appear in the vitreous humour. At first there is little or no pain spontaneously or on pressure. Then more synechiæ form, the iris stroma becomes more indistinct and discoloured, often of a dull greenish or yellowish grey, and the pupil becomes occluded. The anterior chamber becomes shallower than normal, and the intraocular pressure is diminished. Sight is much impeded by exudation in the pupil and by opacities in the vitreous, and, in case of detachment of the retina from shrinking of the inflammatory products in the vitreous humour, it may be reduced in a marked degree. There is often pain on pressure of the eyeball, and the latter soon begins to be diminished in size and becomes soft to the touch, while the pressure of the tendons of the orbital muscles on this soft eyeball gives rise to deep furrows on its surface. In short, the injured eye has now become phthisical, and sight is quite lost. This entire process may be completed in three or four weeks, or it may occupy a considerably longer time.

The danger of sympathetic ophthalmitis supervening on a perforating injury of the first eye commences with the onset of plastic uveitis in the injured eye—although the inflammatory process in the second eye does not develop until after a certain interval (*vide infra*)—and this danger is present, not only all through the acute process in the injured eye, but also after this has subsided, and when the eye has become shrunken, and even for many years more.

Shrunken eyeballs, as just stated, are liable to cause sympathetic ophthalmitis. Pain on pressure of the ciliary region in them, showing, as it does, the presence of inflammation of the ciliary body, is an important danger-signal; but the absence of pain on pressure is not conclusive of the absence of cyclitis, for the latter may exist to only a slight and yet dangerous degree, or the ciliary body may be detached and out of reach of pressure.

The presence of a foreign body in the interior of the injured eye does not necessarily lead to sympathetic ophthalmitis by the inflammatory reaction which it may cause; for an aseptic foreign body in the eye will cause an active inflammatory reaction; yet this latter, not being of bacterial origin, will not in its turn give rise to sympathetic ophthalmitis. There are, however, few foreign bodies, except atoms of hot metal, which can be guaranteed as free from infective material; hence, as a rule, the presence of a foreign body within the eye augments the danger of a perforating injury.

As in accidental perforating injuries, so also the wounds made in the sclerotic or cornea in surgical operations, especially in cataract extractions, may be followed by plastic uveitis, which will produce sympathetic ophthalmitis. In consequence of the thorough antiseptic measures now in use, inflammatory processes after cataract extractions are very much less common than they used to be.

Perforations caused by ulcers of the cornea sometimes give rise to uveitis, which may be followed by sympathetic ophthalmitis; but this is a rare event, although some iritis is present with almost every severe corneal ulcer, and especially with those which tend to perforate. It is not easy to assign a reason for the rare occurrence of sympathetic ophthalmitis in these cases.

In how far plastic uveitis of the first eye, which is not due to perforating injuries or ulcers, is capable of being the cause of sympathetic ophthalmitis is an important question. Intraocular tumours, which have not yet perforated the sclerotic, especially sarcoma of the chorioid, very occasionally set up a uveitis, which leads to sympathotic ophthalmitis. In these cases necrosis of the tumour has generally set in. Again, ruptures of the eyeball from blows, which usually occur in the ciliary region, without rupture of the conjunctiva—subconjunctival ruptures of the sclerotic—sometimes come under our notice (p. 344). They almost invariably run a course free from inflammation, or even irritation of the injured eye, owing to the unbroken conjunctiva, which covers the rupture, and prevents the access of infecting bacteria; and, consequently, they may be said not to cause sympathetic ophthalmitis. It is probable that in the few cases of this injury in which uveitis in the injured eye and sympathetic ophthalmitis in the second eye appeared, there existed some small opening in the apparently sound conjunctiva.

Cases of gonorrhœal ophthalmia have been published in which sympathetic ophthalmitis came on. But these were all cases in which ulceration, followed by perforation of the cornea, took place; and, hence, in which infection by bacteria other than the gonococcus was quite possible.

2. *The Condition of the Sympathising Eye.*—The diseased process in the second or sympathising eye, as has already been stated, is, with certain rare exceptions, an inflammation of the uvea, of a plastic or fibrinous type, but never purulent, and almost always begins in the uvea, or, at any rate,

is commonly first discovered there as iritis. In the rare exceptions referred to, optic neuritis is the first sign of sympathetic ophthalmitis, uveitis coming on subsequently; and, yet more rarely, optic neuritis has been seen as the one and only sympathetic inflammation, the uvea remaining unaffected. It is, however, held by some, that optic neuritis is the first sign in the sympathising eye in nearly all cases, if only they could be examined before opacities in the vitreous humour, and exudation in the pupil, interfere with an ophthalmoscopic diagnosis.

The appearance of the optic neuritis, or papillitis, as seen in these cases, consists in hyperæmia of the disc, without much swelling of it, but with slight woolliness of its margin, the opacity spreading a short distance into the surrounding retina. The veins are distended, and the arteries are normal. The sight is considerably affected, and there is often rather severe headache. The remedy for sympathetic papillitis, occurring alone, is removal of the exciting eye, and a few days after the operation the beneficial effect on the optic nerve inflammation begins to show itself.

There are no reliable premonitory symptoms of the attack of uveitis in the sympathising eye. As already stated, in many cases sympathetic irritation does precede the first signs of sympathetic uveitis, but it does not always do so; and when sympathetic irritation does appear, it need not always indicate the approach of sympathetic uveitis.

The early signs of the actual presence of uveitis in the sympathising eye are:—some fine punctate deposits on the posterior surface of the cornea, and these are often the first symptom; slight peri-corneal injection; slight opacity of the aqueous humour; some discoloration and indistinctness of the iris; contraction of the pupil, but as yet no synechiæ; some fine opacities in the vitreous humour; and slight loss of sight owing to these changes.

Posterior synechiæ soon begin to form, and the adhesions occur in the most serious cases, not merely between the margin of the pupil and the anterior capsule of the lens, but, after a little while, between the whole of the posterior surface of the iris and the capsule—total posterior synechia. The exudation which causes this extensive adhesion soon pushes the iris forward—iris bombé—and renders the anterior chamber shallow; but after a time, when the fibrinous exudation begins to shrink, the anterior chamber becomes deep at its periphery, owing to retraction of the iris. The iris gradually becomes more altered, its tissue more dull, discoloured, and indistinct, while large vessels form in it. Occasionally, in the anterior chamber a small pseudo-hypopyon is seen, formed by the fibrin which floats in the aqueous humour, some of which has gravitated.

The intraocular tension may become high, often very high, owing to blocking of the angle of the anterior chamber with inflammatory products, and this glaucomatous tension is apt to be attended by great pain. In consequence of the presence of such extensive adhesions, eserine and pilocarpine have no influence on this high tension, and the temptation to perform an iridectomy very great. Yet, it may be stated at once, there is no more disastrous mistake in ophthalmic practice than any operative interference at this period. Far from doing good, an iridectomy is almost certain to do harm. It is impossible, owing to the disorganised state of the iris and its close adherence to the anterior capsule, to obtain anything like a satisfactory coloboma; and even if the tension be reduced for a day or two after the operation, it soon becomes as high as before, in consequence of the rapid filling up of the coloboma by proliferation of the inflammatory products, while the traumatism of the operation only seems to lend additional violence to the inflammation.

In the further progress of the disease, the cornea gradually becomes more or less opaque, from derangement of its posterior epithelium by the punctate deposits of fibrin upon it, and the crystalline lens becomes cataractous. After a time the high tension disappears, and gradually, owing to shrinking of the vitreous humour, low tension comes on. Vision, already very bad, sinks further. The eyeball becomes less in size and very soft to the touch, and phthisis bulbi, with complete blindness, is presented. This entire process may occupy many months, and is often interrupted by short periods of slight improvement in the symptoms, which raise the hope of the patient and of the surgeon. Even when phthisis bulbi and complete blindness have come on, danger to the second eye is not at an end, for in these shrunken eyeballs active infective uveitis continues for lengthened periods, or is liable to light up now and then, and to bring on sympathetic mischief.

In rare cases, the sympathetic uveitis comes on with violent pain, chemosis, and swelling of the eyelids, and ends rapidly in phthisis bulbi.

On the other hand, there is a less severe class of cases, in which total posterior synechia does not form, the pupillary margin alone becoming adherent, and these cases may run a comparatively favourable course.

A yet milder, and not uncommon, form of sympathetic uveitis is that in which the only signs are :—punctate deposits on the posterior surface of the cornea, and increased depth of the anterior chamber, without any iritis. The punctate deposits are at first often so fine as to be undiscoverable, unless by aid of a high convex lens behind the sight-hole of the ophthalmoscope, or with a corneal microscope. This form of sympathetic ophthalmitis is termed serous sympathetic uveitis, and its prognosis is favourable. Its one danger consists in the increased intraocular tension which is liable to come on, but which should not tempt the surgeon to employ an iridectomy, whereby a mild process may be converted into a severe one.

More common than this typical serous uveitis are cases in which some fibrin is thrown out, with resulting posterior synechiæ at the pupillary margin, and where small round yellowish-white deposits may be found with the ophthalmoscope in the chorioid—called sympathetic disseminated chorioiditis—especially towards the periphery of the fundus. In some cases the iris is free from inflammation, the chorioid alone being affected in the manner mentioned. This form of sympathetic ophthalmitis is not attended by much irritation of the eye, nor need vision be much affected. The corneal deposits very gradually increase in number, and consequently, vision becomes affected to some extent, and then, if the tension do not increase, the signs and symptoms after a time very slowly abate, and a normal state is re-established. But relapses are liable to occur even after some months, and they may assume the very dangerous fibrinous type. So that, even in these mildest cases, the utmost care in treatment and prognosis is needed.

Removal of the exciting eye does not cure the uveitis in the sympathising eye (*vide infra*).

3. *The Interval that has elapsed between the Injury to the Exciting Eye, and the Onset of Uveitis in the Sympathising Eye.*—So far as our present knowledge based on reliable cases enables an opinion to be formed, the shortest interval which occurs between the injury to the first eye, and the onset of uveitis in the second eye, is fourteen days, and very few cases with this shortest interval have been reported. The period between the sixth and twelfth week after the injury seems to be the most dangerous. In 170 of the 200 cases collected by the Committee on Sympathetic Ophthalmitis of the Ophthalmological Society the second eye was attacked within the first year after the injury to the exciting eye. In only 12 of the 200 cases was the interval more than one year, and the longest interval was twenty years.

4. *The State of the General System.*—As the subjects of

traumatic plastic uveitis in one eye are not immune against plastic uveitis in the other eye due to syphilis, rheumatism, tubercle, diabetes, etc., it is necessary in each case to consider, whether the attack in the second eye may not be a symptom of some systemic condition, rather than a sympathetic uveitis.

From the above it appears, then, that the diagnosis of sympathetic ophthalmitis depends on the following evidence:—(1) As regards the exciting eye: an ectogenic infection; unless in those rare cases where a chorioidal sarcoma produces the infective substance. (2) As regards the sympathising eye: an inflammatory process of a plastic type, which attacks all three portions of the uveal tract, is very chronic in its course, often improves for a while, but relapses again. (3) As regards the interval between the perforating injury in the first eye, and the appearance of sympathetic ophthalmitis: an interval of at least fourteen days is required. The period between the sixth and twelfth week is the most dangerous, and very few cases occur after the first year. (4) As regards the general system: when careful examination of it does not reveal any condition, which might be the cause of uveitis in the second eye, the probability of this uveitis being sympathetic is increased.

Prognosis.—The prognosis of sympathetic uveitis is, in general, serious; yet it need not be quite hopeless, for even in severe cases very occasionally, and of course more frequently in the less severe cases, the sympathising eye does recover after prolonged treatment, with a useful amount of vision. But in these rare cases which undergo cure, the eyes are liable to occasional recurrences of the uveitis, and at least a year should elapse since the last recurrence, before a definite end to the diseased process can be said to have been reached.

The prognosis of sympathetic papillitis is quite favourable, when once the exciting eye has been removed.

Treatment.—Measures calculated to prevent the onset of sympathetic ophthalmitis are of the first importance. Where the injury is so extensive as to make all prospect of saving sight in the first eye hopeless, immediate excision of that globe is obviously indicated. Where some prospect of saving sight in the injured eye exists, attention is claimed in the first instance by the wound, which, in those cases that come for surgical aid sufficiently early, is to be protected from secondary infection by careful antiseptic cleansing, abscission of any prolapsed portions of the uvea, suturing of the wound in suitable cases, and dressing and bandage.

Should the wound be already infected, excision of the injured eyeball is called for. No temporising is admissible —even some useful vision being, for the time, retained by the injured eye is not a contra-indication to the operation.

Where sight in the injured eye is lost, it will not be difficult for the surgeon to recommend excision of the eyeball, and even to urge it on the patient; but when some useful sight is still retained, it is not so easy to press this advice, although that should be done. We know, indeed, that in some cases of traumatic uveitis sympathetic uveitis does not supervene; and, provided the first eye be not too much disorganised by the injury, sight even in it may ultimately be obtained. But, unfortunately, we are unable to foretell whether any given case will run so favourable a course; and to temporise, in the hope that it will do so, involves serious danger to the second eye, and, it may be, ultimate loss of all sight in each eye.

In short, it cannot be doubted that there are cases, in which, in the present state of our knowledge, we recommend removal of the injured eye, and where, had we decided to run a fearful risk by allowing it to remain, not only would sight have been restored to it, but no sympathetic ophthalmitis would have come on.

It must be further stated, that we cannot feel sure, that our removal of the first eye has averted sympathetic ophthalmitis from the second eye, until four weeks after the operation has elapsed. Nearly every ophthalmic surgeon has seen cases in which sympathetic ophthalmitis has appeared subsequently to excision of the first eye, and in which, at the time of the operation, the second eye was perfectly sound. There are well-authenticated cases where sympathetic ophthalmitis appeared as long as four weeks after enucleation of the injured eye. The assumption is that, in these cases, the infective micro-organisms had already gone on their journey to the second eye. These cases are deplorable for the patient, and very trying for the surgeon, especially if the outbreak of sympathetic ophthalmitis should occur very soon after—perhaps the day after—the operation. Yet where sympathetic ophthalmitis comes on after excision of the first eye, the operation need not be regarded as having been quite useless; for experience shows that the attack of uveitis in the second eye is then usually of a comparatively mild type, and fairly amenable to treatment.

In those cases in which the exciting eye has not yet been removed, and in which sympathetic ophthalmitis in the second eye has commenced, what are our duties? In the first instance, and at the earliest possible moment, the exciting eye should be removed, *always provided that it be quite and hopelessly blind.* The immediate result on the second eye of removal of the first eye under these conditions is not marked, for the inflammatory process in the former seems to proceed as actively as before. But statistics show that more sympathising eyes are saved, or partially saved, when the injured eye has been removed soon after the outbreak of sympathetic ophthalmitis than when the injured eye is removed a considerable time after the outbreak, or not at all. Presumably when the source of supply of the infection is withdrawn, the virulence of the sympathetic disease gradually subsides.

But *no exciting eye, which possesses even a slight degree of sight, should be removed when once sympathetic ophthalmitis has appeared.* For it may well happen, that the sympathising eye becomes entirely lost, while the exciting eye ultimately retains some degree of useful sight. Great caution is therefore required in deciding whether the exciting eye is capable of recovering to a certain extent, and this frequently is a matter of considerable difficulty. Even a partially phthisical eyeball may sometimes ultimately come round sufficiently to gain useful vision. Schirmer lays down the following rule:—When sympathetic ophthalmitis has broken out, the exciting eye should not be removed, unless it be absolutely blind; or unless—if it still possess merely perception of light—it has been for several weeks very soft, and reduced in size; or that, by reason of extensive corneal opacity, all hope of restoration of form-vision must be abandoned.

If sympathetic ophthalmitis have broken out, either before or after removal of the exciting eye, the treatment and care of the sympathising eye to promote its recovery must be considered. This consists in the use of atropine, warm fomentations, and subconjunctival saline injections (chap. xv.), which latter are held by some to be very beneficial when high tension is present. With these local means is combined a general and prolonged course of mercurialisation—mercurial inunctions or calomel internally, or both, care being taken to avoid any severe stomatitis. Salicylate of soda is now used in large doses (as much as one hundred and fifty grains in the day) by some surgeons. The patient is to be confined in one warm, but well-ventilated room, which should be kept almost dark. As this treatment must often be carried on for many weeks or even months, it is trying for the patient; but it is to be remembered that the issue at stake is a fateful one.

No operation on the iris is to be performed as long as there is the slightest inflammation, or tendency to inflammation, and this rule holds good, even if the tension of the eye become glaucomatous. Premature operative interference on the iris has only the effect of lighting up fresh inflammation; and, even if the tension be reduced by an iridectomy—which latter, owing to the diseased and degenerated state of the iris and the inflammatory exudation behind it, cannot be satisfactorily carried out—it will soon again become high. In six months or a year after every slight sign of inflammation, or tendency to inflammation—of which injection of the ciliary vessels on insertion of a spring speculum is not a bad criterion—has passed away, and a longer interval can only be of advantage, it may be allowable to perform an operation with the object of making an artificial pupil, always provided that there is good prospect of materially improving vision by this means. It must be remembered that, while every operation has its risks, the risks are unusually great in such disorganised eyes; and that any loss of sight is felt all the more in a case, in which the eye operated on is probably the only one possessing even a little vision. On the other hand, when success crowns an operation in these sad and perplexing cases, the gain is great.

If it be decided not to remove the exciting eye, after sympathetic ophthalmitis has broken out, then the inflammatory process in it is treated on lines quite similar to those above recommended for the sympathising eye, and the advice as regards operations is the same.

Prophylactic Operations used for Sympathetic Ophthalmitis, performed on the exciting eye.

Enucleation (*or Excision*).—Of prophylactic operations for sympathetic ophthalmitis, enucleation of the first eye is the only one which is regarded by all ophthalmic surgeons as thoroughly reliable, when it is performed in time.

The speculum having been inserted, an incision is made in the conjunctiva all round the cornea, and about 6 mm.

removed from the latter. The bulbar conjunctiva is separated from the globe freely in all directions with a scissors. With a strabismus hook each orbital muscle is caught up, and its tendon divided close to the sclerotic. The optic nerve is then divided with a strong scissors passed into the orbit, either from the median or from the temporal side, as far back in the orbit as possible. Finally the edges of the conjunctiva are drawn together with a few points of suture.

Careful aseptic and antiseptic precautions are to be employed in connection with enucleation of the globe. Of these, next to thorough sterilisation of the instruments, irrigation of the cavity of the orbit as soon as the eyeball is removed, with a full stream of sublimate solution, 1 in 5000, or of sterilised normal salt solution is the most important. After the sutures have been applied, the interior of the orbit is well covered with xeroform, or other fine antiseptic powder, and an aseptic dressing is applied with a bandage. The orbit should be similarly dressed every twenty-four hours.

Some cases of meningitis following upon the operation, and which have proved fatal, are reported. There can be no reasonable doubt but that, in these instances, septic matter made its way along the lymphatics of the optic nerve to the meninges, and that this septic matter was introduced upon the instruments, or escaped, in purulent cases, from the interior of the eyeball. Hence the very great importance of the careful aseptic precautions above indicated.

An artificial eye (prothesis oculi) can usually be inserted after a fortnight, but should not be constantly worn for a month at least, as, until that period elapses, it is liable to cause irritation and conjunctivitis.

* *Evisceration.*—For mode of performing this operation, *vide* p. 256. Evisceration is not held to be so good a safeguard against sympathetic ophthalmitis as excision,

and is not employed for that purpose, unless where it is performed quite soon after the injury, or at any rate before uveitis has commenced. The advantage of evisceration over enuclcation lies in the better stump provided by it for a prothesis, and the consequent better cosmetic effect.

* *Mules' Operation.*—For the description of this operation see p. 257. The objections to and advantages of this operation are the same as in evisceration, but it gives a better stump than the latter.

* *Adams Frost's Operation* (p. 259).—The same remarks apply to this method.

Therapeutic Operations used in Sympathetic Ophthalmitis.—The field for these operations, if it exist at all, is exceedingly limited. Practically the only indication for operative interference, in the active period of sympathetic ophthalmitis, is long-continued high tension; and in the foregoing pages the warning has been repeatedly uttered, that any operative meddling with the iris in this period is more apt to aggravate the process than to alleviate it; and that, even if tension be relieved by an iridectomy, it soon becomes high again, owing to fresh plastic exudation.

Should it seem imperatively necessary to endeavour to reduce a long-continued high tension, sclerotomy is to be preferred to iridectomy. It may have a beneficial effect, and is not likely to do harm. It can be repeated more than once, should it be deemed necessary.

Paracentesis of the cornea is a measure which can be used as a temporary means of relief for high tension, and it, too, may be repeated.

* **Optical Operations used in Sympathetic Ophthalmitis.**—The object of these operations is to provide an artificial pupil in the sympathising eye after all inflammation, or tendency to it, has ceased, in order to improve, or to restore, vision which is interfered with by closure of the

pupil. Similar operations may be indicated occasionally in the exciting eye, in cases where it has not been excised.

The cardinal point to be borne in mind, it may again be stated, is, that these operations must never be performed until six months at least have elapsed—and a longer period is preferable—after all and every tendency to inflammation, or irritation, has subsided. Inattention to this rule will result in a re-lighting of the inflammation, re-closure of the pupil which may have been made, or intraocular hæmorrhage, and a long period of waiting before any further operation can be undertaken, or else the globes may become shrunken, and all hope may be at an end.

Moreover, as, even under the most favourable conditions, and with the most skilful operation, inflammation may return, or intraocular hæmorrhage may occur, or the eye may become phthisical, no operation should be done unless the advantage to be gained from it, if successful, promises to be considerable.

The three chief operations, one or other of which may be applicable, are:—Iridectomy, extraction of the clear or cataractous lens—for the lens is often cataractous from interference with its nutrition by reason of the irido-cyclitis—or discission of the cataractous lens.

Iridectomy.—It is only exceptionally that iridectomy can be of use, in those eyes which have been the subjects of the severer plastic uveitis, resulting in total posterior synechia. In these cases, the tissue of the iris has undergone such extreme degeneration, that it is impossible to obtain more than mere shreds of the membrane with the forceps, so that a satisfactory coloboma can rarely be made. Or, if a fairly good coloboma be procured, it will probably be found that the pigmentary layer of the iris is left behind; and that this, with organised inflammatory products, lies on the anterior capsule, and obviates any gain that might have been derived from the coloboma.

Iridectomy is indicated rather in those cases, where a less severe form of iritis has existed, resulting in a complete ring synechia of the pupillary margin only. Here a wide coloboma may often be made satisfactorily. The iris should be seized with the forceps at about the lesser circle. If seized at the pupillary margin, the intimate adhesion between the latter and the lens capsule may cause injury to the capsule, and consequent traumatic cataract.

Extraction of the Lens.—This is indicated, if, on the formation of a coloboma, the lens be found to be cataractous, in those cases of ring synechia where iridectomy has been performed and the coloboma has closed again; and in practically all cases of total posterior synechia, be the lens clear or opaque. In the former class of cases the ordinary combined method of cataract extraction answers the purpose, or a preliminary iridectomy may be made some weeks previously.

Cases of total posterior synechia require a procedure. Such as one or other of the following:—

Wenzel's Method.—The puncture, counter puncture, and incision are the same as in an ordinary cataract extraction, but the knife on entering is passed through cornea, iris, lens, iris, cornea. The lens is thus delivered as completely as possible, and out of the membrane composed of degenerated iris, retro-iridic connective tissue, and capsule, a V-shaped piece is cut with the forceps-scissors. The traumatism of this operation is great, and not every globe will bear it, and phthisis bulbi may follow.

Hirschberg's Method.—An incision is made with a keratome in the lower margin of the cornea. With a fine capsule forceps, introduced into the pupil, the thickened anterior capsule is seized and drawn away and, by inserting a spatula, as much of the lens as possible is extracted. Some weeks later the pupillary membrane, composed of lenticular remains, posterior capsule, and inflammatory products, is divided with a cystotome. In this operation it is an advantage that the iris is not interfered with.

Discission.—This operation was employed by the late Mr. George Critchett with success, in some cases where cataract was the main obstruction to sight. A discission needle is passed, by a boring motion, through the lenticular capsule ; another needle is then passed in close to the first, and by separating one point from the other a rent is made. This is followed generally by the escape into the anterior chamber of a small quantity of cheesy lens matter, which becomes gradually absorbed, and in the course of some weeks the capsule closes again. The operation has to be repeated several times before a clear pupil is obtained, care being taken that all irritation from the previous operation has subsided before another be undertaken. The chief danger in this operation is irritation and high tension, from swelling of the lenticular masses in the disorganised eye.

Pathogenesis.—The pathogenesis of sympathetic ophthalmitis is still obscure. There are two chief theories, each of which relies on infection by a specific micro-organism introduced into the exciting eye at the time of the injury, and which passes from it to the sympathising eye. But these theories differ from each other in respect of the path by which they would make the micro-organism pass from the first to the second eye. According to one theory the path is by the lymphatics of the optic nerve of the exciting eye, or its sheaths, then by the optic commissure, and optic nerve of the sympathising eye—in short, by direct continuity, as erysipelas extends over the skin. According to the other theory—which recent investigations seem to render the more probable of the two—micro-organisms enter the bloodvessels of the first eye, and are carried by the blood-stream through the body, but are pathogenetic only for the uveal tract of the second eye.

Pathology.—Hitherto the specific micro-organism of sympathetic ophthalmitis has evaded detection by every method. Quite recently Zur Nedden has discovered a pseudo diphtheritic-like bacillus in the blood of a patient suffering from sympathetic ophthalmitis, and which may be the micro-organism in question. The inflammatory products, both in the exciting and in the sympathising eye, are of twofold nature:—1. A tough organised connective tissue containing few nuclei, which is developed on the surfaces of the iris, ciliary body, and retina. 2. An infiltration of the stroma of the uveal tract with lymphocytes, epithelioid cells, and giant cells (Fuchs). This second product of inflammation is held by Fuchs to be the result of infection by the specific micro-organism which causes sympathetic ophthalmitis, while he regards the connective tissue development as an accidental complication, due to infection by simultaneous entrance into the injured eye of another micro-organism. The clinical appearances and symptoms are due as much to the one as to the other product, and it cannot be known in any given case whether the essential product of the specific micro-organism be present in the first eye.

INJURIES OF THE UVEAL TRACT.

Injuries of the Iris.—*Punctured Wounds* of the cornea, or of the corneo-scleral margin, frequently implicate the iris, but rarely do so without also injuring the crystalline lens or ciliary body, on which then the chief interest centres, as being the organs from which serious reaction is most likely to emanate. A small simple incised wound of the iris is not of great importance, for inflammatory reaction is not common, and any extravasation of blood at the seat of the iris wound, or into the anterior chamber (hyphæma) becomes absorbed, while, in most cases, the functions of the iris will probably not be affected nor sight endangered. Nevertheless, as iritis does sometimes occur, it is desirable to use such measures as are calculated to prevent it, such as atropine, a bandage, and rest of the eye and general system. Even extensive wounds of the iris are not often, as such, associated with serious danger to the eye, although the loss of continuity in the iris never closes up. Where, for instance, the iris is cut in its entire width from ciliary margin to pupillary margin, the permanent result is a wide coloboma, the margins of which may be adherent to the corneal wound. When the iris is prolapsed in the corneal wound, every effort should be made to reduce it completely; and, if this cannot be effected, it is necessary to abscise the prolapsed portion. Incarceration of the iris in the corneal cicatrix may lead to secondary glaucoma, cystoid cicatrix, secondary septic infection of the iris, etc.

Foreign Bodies of small size, such as bits of steel or iron, may perforate the cornea and fasten in the iris, the puncture in the cornea closing rapidly, and possibly no aqueous humour being lost. It is necessary always to remove such a foreign body without delay, although for some time it may cause no reaction. An incision should be made with a Græfe's knife at the margin of the cornea, corresponding to the position of the foreign body, and the portion of iris containing the foreign body is then removed with forceps and scissors.

Blows on the Eye are apt to cause, in addition to hæmorrhage into the anterior chamber from the iris or from the canal of Schlemm, one of several remarkable lesions of the iris, namely:—

1. *Iridodialysis*[1]—*i.e.*, separation of the iris from its attachment to the ciliary body, which is usually accompanied by considerable hyphæma. As much as one-half of the circumference of the iris may be involved in the lesion; or the latter may be so small as to be diagnosed only by the presence of the resulting small fresh hæmorrhage near

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[1] ἶρις, διάλυσις, *a separating.*

the ciliary margin of the iris; or, after this has become absorbed, by aid of light transmitted to the eye by the ophthalmoscope, when not alone the physiological pupil, but also the minute marginal traumatic pupil will be illuminated. It is rarely that there is more than one dialysis. In certain degrees of the detachment, by reason of the sphincter of the iris having lost its fixed point, it becomes stretched in a straight line (Fig. 151) at the part corresponding to the dialysis, and assumes a D shape; or if the detachment be more extensive, the pupil becomes kidney-shaped; or the detached portion may entirely cover the pupil. The detached portion, too, may be turned on itself (anteflexion of the iris), the uveal surface being to the front. The functions of the eye after such an injury, even when extensive, are sometimes but little disturbed, or there may be monocular diplopia.

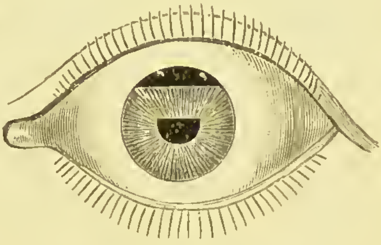
FIG. 151.

It is stated that iridodialysis does not become re-attached; but a case has come under the notice of one of us in which a very minute iridodialysis was healed, and another such case is recorded. The lengthened use of atropine is the most likely way in which to promote such a result, but it can only be hoped for if the iridodialysis be not extensive, and if the case be seen early.

Iridodialysis does not increase in extent in the course of time, nor lead to further mischief in the eye.

* 2. *Retroflexion of the Iris.*—From a blow on the eye the whole, or more commonly a portion, of the iris in its entire width can be folded back on the ciliary processes, giving the appearance of a very dilated pupil, or of a coloboma produced by a wide and peripheral iridectomy. In a true coloboma the ciliary processes would be easily seen, but not so in retroflexion, for the processes, being covered by

the retroflexed iris, present a smooth surface. A slight dislocation of the lens in the direction away from the iris lesion is often observed. Retroflection of the iris cannot be cured, but useful vision is retained, if the injury be uncomplicated.

* 3. *Rupture of the Sphincter Iridis.*—There are not many cases of this lesion recorded. There may be but one rupture, or there may be a number of small ruptures distributed round the pupil. They show themselves as small triangular gaps in the pupillary margin, their bases directed towards the latter. This condition is also incurable, and some permanent disturbance of vision due to the mydriasis results.

* 4. *Dehiscence of the Iris* between the pupillary and ciliary margins. This is a slit-like rupture of the iris, which runs in a radial direction through the whole width of the iris, with the exception of the sphincter. The diagnosis sometimes cannot be made with certainty until, after a few days, the blood-clot covering the dehiscence is absorbed. The opening may be caused to close by the use of a myotic, which, by contracting the sphincter, brings the edges of the dehiscence together.

* 5. *Traumatic Aniridia.*—The whole iris is torn from its ciliary insertion, and may be found lying in the anterior chamber or under the conjunctiva, having in the latter case passed through a rent at the corneo-scleral margin. Not only does the anterior chamber contain blood, but the vitreous humour is often infiltrated with hæmorrhage. When the extravasated blood has become sufficiently absorbed, the absence of the iris will be noted, and in many instances the ciliary processes will be visible. If these latter are visible, the diagnosis ‘aniridia’ can be definitely made, but cases do occur in which, notwithstanding the absence of the iris, the ciliary processes are not visible, owing probably to changes in the processes which cause

them to shrink. Such cases then are difficult to distinguish from retroflexion of the iris, but the importance of the diagnosis is not great.

6. *Traumatic Mydriasis, and Myosis.*—Of these, mydriasis is the more common. The dilatation is of medium degree, and the pupil is usually of irregular shape—oval, pear-shaped, or more dilated at one part than elsewhere—and contracts but slightly, or not at all, to light. Paralysis of accommodation usually accompanies traumatic paralysis of the sphincter iridis. The mydriasis is probably the result of concussion of the delicate nerve-endings in the sphincter of the iris. (See above, under Rupture of the Sphincter Iridis.) Traumatic mydriasis may recover after a long interval, but in most instances it remains as a permanent defect, with some derangement of vision due to it and to the paralysis of accommodation.

With traumatic myosis there is apt to be spasm of accommodation, which may produce apparent myopia. The prognosis is fairly good.

Treatment.—For mydriasis, protection spectacles, galvanism, and eserine. For myosis, atropine.

Injuries of the Ciliary Body.—*Punctured Wounds, and Foreign Bodies* perforating the sclerotic at a distance of about 5 mm. around the cornea, are almost certain to implicate the ciliary body. If there be no prolapse of the ciliary body, nor any foreign body in the interior of the eye, the sclerotic wound may heal by aid of a bandage without further ill results. If a prolapse of the ciliary body or iris be present, it is to be abscised, with careful antiseptic measures; and if the sclerotic wound be large, it may be thought desirable to unite its margins with sutures.

Wounds of the ciliary body are apt to cause cyclitis, especially if the former be incarcerated in the sclerotic wound in healing, for the incarcerated portion is liable to become infected.

* **Injuries of the Chorioid.**—*Small Foreign Bodies* may pierce the sclerotic, or the cornea and lens, and may lodge in the chorioid, and, if favourably situated, can then be detected with the ophthalmoscope, and always by the Röntgen rays if of metal (see chap. xv.). These foreign bodies require operative removal by the magnet, if of steel or iron (see chap. xv.); or, if the foreign body cannot be extracted, the eyeball must be removed, to avert sympathetic ophthalmitis.

Incised Wounds of the sclerotic very frequently involve the chorioid (see p. 344).

Rupture of the Chorioid near the posterior pole of the eye is often produced by blows on the eye, and is seen with the ophthalmoscope as a whitish-yellow (the colour of the sclerotic) crescent some two or three papilla-diameters in length, and one papilla-diameter or so distant from the optic entrance, the concavity of the crescent being directed towards the latter. Immediately after the accident extravasated blood sometimes prevents a view of the rupture. Some chorioiditis may result; but, when this passes away, good vision is frequently restored and maintained, provided detachment of the retina does not ultimately supervene from cicatricial contraction at the seat of the rupture. On the other hand, a scotoma in the field may be produced, and if the rupture be in the region of the macula lutea, serious loss of sight may be caused.

Treatment.—Careful protection of the eye, and abstinence from use of it, with dry cupping at the temple for three weeks, or until it may be assumed that all inflammatory tendency has subsided.

Blows upon the eye may cause *Extravasation of Blood in the Chorioid.* If small, these extravasations do not extend beyond the chorioid. But, in the case of copious extravasation, the hæmorrhage is poured out from the chorioidal vessels between that coat and the sclerotic, lifting and bulging forward the chorioid; or between the chorioid and retina, giving rise to a detachment of the latter; and if the retina give way, the blood is poured out into the vitreous humour. Should there be no vitreous humour opacity, the extravasations in the chorioid can be seen with the ophthalmoscope as somewhat indistinct (owing to resulting opacity in the overlying retina) small red spots, or large round red spots, darker in the centre than at the margin. That these hæmorrhages are in the chorioid can be recognised from the fact that they lie behind the retinal vessels. The hæmorrhages become slowly absorbed, and after a time, provided they have not ruptured the retina, useful vision may be restored.

Treatment.—Complete rest in bed. Atropine. Bandage.

NEW GROWTHS OF THE UVEAL TRACT.

***New Growths of the Iris.**—*Cysts.*—These vary from a very small size to that which would fill the anterior chamber. They may have either serous or solid contents. The serous kind was held to result always from a trauma causing an anterior synechia, or otherwise shutting off a fold of the iris, which became distended into a cyst by accumulation of aqueous humour. A case, however, which was not preceded by a trauma has come under notice at the Victoria Hospital. The cysts with solid contents (epidermoid elements) are believed to have their origin in an eyelash or morsel of epidermis, which may have made its way into the anterior chamber by occasion of a perforating corneal wound. All these cysts are sources of serious danger to the eye (irido-chorioiditis, glaucoma, etc.), and, it has been stated, may even be the cause of sympathetic ophthalmitis, and hence their removal is called for. This can be effected without much difficulty if the tumour be small, but if it have attained a large size the attempt is often unsuccessful. A long incision should be made in the corneo-scleral margin, and the cyst, along with the portion of iris to which it is attached, drawn out and cut off.

Granuloma is the name given to a benign neoplasm of the iris, of which the structure resembles granulation tissue. Clinically it is a small pale tumour, or there may be several such tumours, which gradually grow to fill the anterior chamber, rupture the cornea, and finally induce phthisis bulbi. It is held by some that these growths depend on a syphilitic taint, and by others that they are tubercular.

Solitary Tubercle.—Solitary tubercle may be accompanied by a few smaller growths, but it generally begins as a single yellowish-white tumour, often without iritis, which gradually increases in size until it may fill the anterior chamber. It finally involves the cornea, which it perforates, forming a fungating mass, and this subsequently breaks down, leaving only a small shrunken globe in the socket.

Treatment.—Tuberculin in the early stages, and if perforation should take place excision of the eyeball

Sarcoma.—Of the uveal tract, the iris is the portion most rarely affected with primary sarcoma. It arises usually from a congenital pigmented nævus of the iris, and is commonly a melano-sarcoma; but leuco-sarcoma has also been recorded. As the tumour increases in size, it fills the anterior chamber, and grows backwards into the ciliary body and into the canal of Schlemm. It is not usual for the tumour to become extraocular by growing through at the corneo-scleral margin, and in this respect it is unlike tubercle of the iris. Irritation or inflammatory symptoms are not often present, and secondary glaucoma does not come on until a later stage, when the growth has filled the anterior chamber, or involved the ciliary body extensively.

Treatment.—Enucleation of the eye should be advised as soon as the diagnosis of sarcoma of the iris has been made. There is naturally a desire on the part of the surgeon, when the tumour is small, to save the eye, which probably has full vision, by excising the portion of iris in which the growth is seated, and there are some cases on record in which this was done, and where no recurrence of the tumour took place. But in adopting this conservative method, the surgeon accepts grave responsibility; for it is not possible to determine clinically whether the sarcomatous growth is truly, or only apparently, confined to the limited region of the iris, where it can be seen. Even in the early stages of many cases of sarcoma of the iris, the neoplasm invades the ligamentum pectinatum, the canal of Schlemm, or the ciliary body; so that, although the iris tumour be thoroughly removed, the growth reappears in the eye before long, while in the meantime risk of infection of the general system has been run.

Carcinoma.—Two or three cases of metastatic carcinoma of the iris and ciliary body are on record, with the breast as the primary seat of disease.

Ophthalmia Nodosa.—See p. 176.

***New Growths of the Ciliary Body.**—*Sarcoma* of the ciliary body is generally pigmented, and often passes unobserved, until it attains considerable size as a brown mass, which was at first concealed from view by the iris. Occasionally it is first noticed when it makes its appearance at the angle of the anterior chamber. It usually also grows backwards into the chorioid, and runs the same course as sarcoma of the chorioid, but in rare cases extends round the whole ciliary region (ring sarcoma). Removal of the eyeball should be urged, but is often for a time declined by the patient, as sight is but slightly affected in the early stages.

Myosarcoma originating in the ciliary muscle has been observed a few times.

Carcinoma.—Secondary carcinoma may occur in the ciliary body as in the iris and the chorioid, but is very rare.

***New Growths of the Chorioid.**—*Sarcoma* is by far the most common neoplasm of the chorioid, and the chorioid is the most common seat of ocular sarcoma. It is seen at all times of life, but most frequently between the ages of forty and sixty. Both melano-sarcoma and leuco-sarcoma occur, and may originate in any part of the chorioid.

If seen in a very early stage, it is easily recognised from its projecting over the general surface of the fundus, the retina lying closely applied to it; but, unless it be in the region of the macula lutea, it may not cause any serious disturbance of vision, and hence may not at that period be brought under the notice of the surgeon. The diagnosis from detachment of the chorioid at this stage is made by the presence in the latter condition of the characteristic chorioidal vessels, and by the peculiar colour of the chorioid. Detachment of the chorioid, too, is much rarer than sarcoma.

The new growth soon gives rise to detachment of the retina, by reason of serous exudation from the chorioid; and this may be accompanied by opacity in the vitreous humour, which contributes in rendering the diagnosis with the ophthalmoscope difficult or impossible. If the detachment be shallow and the retina translucent, the tumour may still sometimes be seen through the sub-retinal fluid by aid of strong illumination; and even direct sunlight may be employed in some such cases. Often the detachment commences at a part of the fundus not immediately over the tumour, but some distance removed from it. Owing to the great, and often sudden, defect of vision which comes on in this stage, we very commonly see these cases now for the first time. The history of the case may aid us; while the absence of the more usual causes of detachment of the retina should make us suspicious of an intraocular tumour, and the fundus should be carefully examined, with dilated pupil, in all such cases.

At this and at later stages, Leber's Sclerotic Transilluminator (Fig. 152, $\frac{1}{3}$ size) is a valuable diagnostic aid. It consists of a small electric lamp (*b*), which requires a current of eight to ten volts, enclosed in a metal jacket (*a*). The anterior end of the lamp is in contact with a short glass rod (*c*) covered with a hard rubber sheath. The light of the lamp is transmitted along the glass rod, and the exposed end (*d*) of the latter is placed on the sclerotic of the cocainised eye, in a dark room. Then, if the eye be normal, or even if a ripe cataract be present, the pupil lights up with the familiar red glow from the chorioid. But if, internal to the spot at which the glass rod is applied, a new growth be present, the pupil does not light up—it remains dark. By slipping the rod over the whole of the suspected region, or as much of it as can be reached, or, indeed, over the whole exposed sclerotic, it can be ascertained whether an intraocular growth be present. The only limitation to the method is in those cases where the tumour is situated much behind the equator, a region in which the rod cannot be brought in contact with the sclerotic.

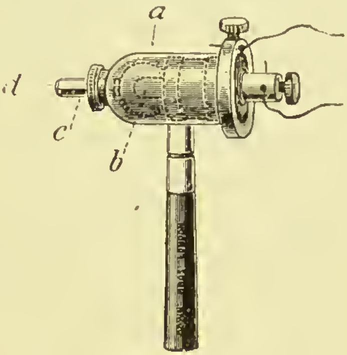

FIG. 152.

Soon the intraocular tension increases. This makes the diagnosis again more easy in many cases, for the combination of detached retina and increased tension exists only with intraocular tumours. The increased tension may come on very slowly, and without ciliary neuralgia ; or more rapidly, and with all the signs and symptoms of acute glaucoma. Yet, if the case come under observation now for the first time, the diagnosis may be by no means easy, should the refracting media be opaque (as always in acute glaucoma), and consequently the detachment of the retina concealed from view. Here, again, the history of the case is all we have to depend on, especially the fact of the patient having noticed a defect at one side of his field of vision previous to the onset of glaucoma.

In the next stage of the growth it perforates the cornea or sclerotic, and, increasing rapidly in size, although still covered with conjunctiva, it pushes the eyeball to one side, the upper lid being stretched tightly over the whole. On raising the lid the tumour is seen as a bluish-grey mass with irregular surface. The conjunctiva is now soon perforated, and the surface of the tumour becomes ulcerated, with a foul-smelling discharge and occasional hæmorrhages. The tumour gradually invades the surrounding skin and the bones of the orbit, and by extending through the sphenoidal fissure and optic foramen reaches the base of the brain.

Another, and much less usual, course of chorioidal sarcoma, is that in which, without first perforating the cornea or sclerotic, the tumour sets up irido-cyclitis, leading to phthisis bulbi. Cases in which sarcoma of the chorioid was found in shrunken eyeballs have given rise to the view that such eyeballs are prone to develop sarcoma. While it is quite possible that sarcoma may develop in a shrunken eyeball, it is tolerably certain that, in the majority of the cases in which both diseases are present, the sarcoma is the primary disease, and undergoes more or less necrosis.

Sarcoma of the chorioid very occasionally gives rise to sympathetic ophthalmitis (pp. 378, 383).

It is usually upon the neighbouring tissues of the eyeball becoming involved that secondary growths begin to form in other organs, the one most prone to be affected being the liver. The lungs, stomach, peritoneum, spleen, and kidneys may all be attacked.

Chorioidal sarcoma is almost always primary, but it has been seen a few times as a metastatic disease.

Carcinoma.—This is extremely rare, and the cases of it on record were all of metastatic origin, the primary disease being in the breast. It is not possible to distinguish chorioidal sarcoma from chorioidal carcinoma by the ophthalmoscope.

Tubercle is sometimes seen in cases of acute miliary tuberculosis as round, slightly prominent, pale yellowish spots, of sizes varying from 0·5 to 2·5 mm. in diameter, situated always in the neighbourhood of the optic papilla and macula lutea, and unaccompanied by pigmentary or other chorioidal changes. There may be but one of these tubercles, or there may be many of them. When they occur, it is, as a rule, in a late stage of the general disease, but they have occasionally been noted long before its appearance. In obscure cases of the general disease, the ophthalmoscope has sometimes rendered valuable diagnostic aid by discovering these minute tubercles in the chorioid.

Very rarely does a tubercular tumour grow in the chorioid in cases of general chronic tuberculosis, attaining to a large size, and destroying the eye similarly as sarcoma or carcinoma. In young children it may be impossible to diagnose between a tubercular tumour of the chorioid and a glioma of the retina (chap. xvi.). Yet, as in either case enucleation is indicated, the diagnosis is not of much practical importance.

Other, but rare, forms of tumour of the chorioid are :—

Sarcoma Carcinomatosum, *Osteo-Sarcoma*, and *Lymphoma*.

Treatment.—So long as, in cases of sarcoma and carcinoma, the tumour is wholly intraocular, enucleation of the eyeball should be performed, and may be done with fair hopes of saving the patient's life, if the disease be primary. When the orbital tissues have become involved, extirpation of all the contents of the orbit, and even, if necessary, removal of portions of its bony walls, ought to be undertaken, should the general health permit, in order to rid the patient of his loathsome disease ; although the probable presence of secondary growths elsewhere renders but small the prospect of saving the patient's life.

Cases of miliary chorioidal tubercle do not call for direct treatment.

In cases of tubercular tumour the question of removal of the eyeball must depend upon the general state of the patient ; but, if it seem probable that life will be prolonged until after the ocular growth would have become extra-ocular, removal of the eye should be recommended.

***Other Diseases of the Chorioid.**—*Posterior Sclero-Chorioiditis, or Posterior Staphyloma.*—This condition is described in connection with myopia (p. 54), which is its almost constant cause.

Detachment of the Chorioid.—As the result of copious loss of vitreous, during operations, or from injury, detachment of the chorioid is not uncommon, but it does not require to be specially diagnosed in these instances, and therefore it is not important to consider it further here.

Idiopathic detachment of the chorioid is extremely rare. Its ophthalmoscopic appearances are apt to be taken at first sight for a simple detachment of the retina, or for leuco-sarcoma ; but on closer inspection the chorioidal stroma is observed to lie immediately behind the detached retina, and its vessels, etc., are seen in the upright image by aid of the same lens as are the retinal vessels. The chorioid is not everywhere detached, but is separated from the sclerotic in several different places, and these detachments are seen in the form of apparently solid hemispherical protuberances rising abruptly from the fundus into the vitreous humour. In other places the chorioid is in contact with the sclerotic, although in some of these positions there may be detachment of the retina alone. The vitreous humour is more or less opaque. Vision is greatly lowered or quite destroyed.

It is probable that a chronic chorioido-retinitis has been an antecedent condition in all of these cases. Indeed, there often are signs of old retinitis present, such as perivasculitis and connective tissue striation; and in one case a retinitis was actually observed long before the detachment of the chorioid came on. Adhesions between the chorioid and sclerotic are formed in consequence of this inflammation; and then inflammatory exudation takes place behind the chorioid, and separates it from the sclerotic, where it is not adherent to the latter.

The process ends either in phthisis bulbi, in consequence of vascular changes and disturbances of nutrition, or in cure of a certain degree, in so far as by absorption of some of the exudation, and by alteration of the remainder of it into connective tissue, a return of the chorioid and retina to their normal position is rendered possible; but even then restoration of sight, with tissues so disorganised, cannot be looked for.

Treatment hitherto seems to have been of no avail. Probably active mercurialisation might afford the best chance of doing good, should a case come under notice.

Fuchs has pointed out that detachment of the chorioid occurs in a good many cases of cataract extraction some days after the operation, although there has been no loss of vitreous, and also in some cases of iridectomy. It can often be found with the ophthalmoscope, and even sometimes with the oblique illumination, in those cases of cataract extraction in which the anterior chamber has not formed, or in which, having formed, it has become empty again. It is mainly after iridectomy for chronic simple glaucoma that chorioidal detachment has been noticed. The probable explanation is, that a slight aperture of communication has been made between the anterior chamber and the sub-chorioidal space, through which the aqueous humour passes behind the chorioid. With the re-establishment of the anterior chamber, the chorioidal detachment goes back, and the prognosis is in all cases good as regards vision.

**Central Senile Areolar Atrophy of the Chorioid.*—This is not a very rare disease, and presents the appearance of a white patch, often of considerable extent, at and around the macular region. In some cases a hæmorrhage in the chorioid and posterior layers of the retina forms the starting-point of the disease. The retinal functions always suffer much ; for an absolute central scotoma is produced, which renders reading and writing impossible, although locomotion is not greatly impeded, as the periphery of the field remains intact. The discovery of the presence of this disease, after a cataract has been successfully removed, is sometimes a source of intense disappointment both to patient and surgeon, which cannot be guarded against unless the condition of the fundus oculi have been noted while the cataract was still incipient.

Treatment is of no avail, but absolute rest of the eyes from all attempts at near work, and the use of dark protection spectacles are important, so that, at the least, the advance of the disease may not be encouraged.

MALFORMATIONS OF THE UVEAL TRACT.

***Malformations of the Iris.**—*Heterophthalmos* (*ἕτερος, different ; ὀφθαλμός*).—This term indicates that the colour of the iris in one eye is different from that in the other.

Corectopia (*κόρη, the pupil ; ἔκτοπος, out of position*), or malposition of the pupil. The pupil sometimes occupies a position farther from the centre of the iris than normally.

Polycoria (*πολύς, many ; κόρη, the pupil*).—Where there is more than one pupil. The supernumerary pupil may be separated by only a small bridge from the normal pupil, or it may be situated very near the periphery of the iris. In neither case has it a special sphincter.

Persistent Pupillary Membrane appears in the form of very fine threads stretched across the pupil. They cannot be mistaken for posterior synechiæ, as they are attached to the anterior surface of the iris some distance from the margin of the pupil. They do not interfere with the motions of the pupil, nor with vision.

Coloboma (κολοβός, *maimed*) and *Irideremia* (ἴρις, the iris ; ἐρημία, *want of*).—These two defects have been shown by Treacher Collins to be due to a similar cause—in short, that they are different degrees of one and the same condition. Before the iris is formed in the fœtus there exists, between the posterior surface of the cornea and the anterior capsule of the lens, the anterior portion of the fibro-vascular sheath. This receives its blood-supply partly from the ciliary arteries, and partly from those in the posterior fibro-vascular sheath, prolonged round the sides of the lens to join it. The cornea, anterior fibro-vascular sheath, and lens lie in close contact with each other. The iris is developed by growing forwards from the margin of the anterior chamber, and in doing so has to insinuate itself between the cornea and anterior fibro-vascular sheath on the one side and the lens on the other, pushing the prolongation from the posterior fibro-vascular sheath in front of it. The anterior fibro-vascular sheath subsequently becomes the pupillary membrane, of which portions sometimes persist (see above). If we suppose some abnormal adhesion to occur between the cornea, anterior fibro-vascular sheath, and lens-capsule, or some delay in their separation at the whole circumference of the future anterior chamber, we can understand how a mechanical obstruction to any growth of the iris forwards would be introduced, resulting in complete absence of the iris, or irideremia. If the obstruction be confined to a portion only of the anterior chamber, the corresponding portion only of the iris will be prevented from growing forwards, and the result will be one or more congenital colobomata. Irideremia may be complete or partial. In the latter case it may be the inner circle only which is wanting, giving the pupil the appearance of dilatation with atropine. Where the entire iris is absent the ciliary processes can be seen all round. The condition may be binocular. The patients suffer chiefly from dazzling by light, from which either protection or stenopæic spectacles afford some relief.

***Malformations of the Chorioid.**—*Coloboma.*—This is a solution of continuity occurring always in the lower part of the chorioid, and usually associated with a similar defect in the iris. It may commence at the optic papilla, and involve the ciliary body also, and even the crystalline lens may have a corresponding notch; or it may not extend so far in either direction. The condition is recognised ophthalmoscopically by the white patch, due to exposure of the sclerotic where the chorioid is deficient. Sometimes the retina is absent over the defect in the chorioid, a circumstance which may be ascertained by the arrangement of the retinal vessels; but, even if it be present, its functions at that place are wanting, and a defect in the field of vision exists. Central vision is often normal.

Albinismus, or the want of pigment in the chorioid and iris. This is usually accompanied by defective pigmentation of the hair of the body. The iris has a pink appearance, due to reflection of light from its blood-vessels, and from those of the chorioid, and with the ophthalmoscope the latter vessels can be seen down to their finest branchings. The light which enters the eye, not being partially absorbed by pigment, causes the patient much dazzling, and high degrees of the condition are usually accompanied by nystagmus. In childhood the albinismus and attendant symptoms are more marked than later in life, when some degree of pigmentation usually takes place.

Much advantage may be derived in many of these cases by the use of stenopæic spectacles, at least for near work. Any defect of refraction should be carefully corrected, in order to give the patients the best possible use of their eyes.

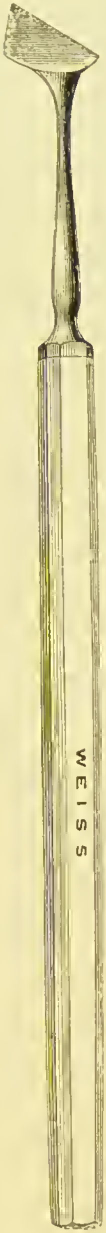

FIG. 153.

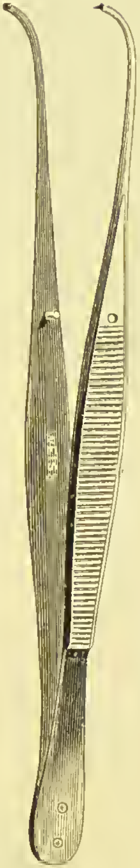

FIG. 154.

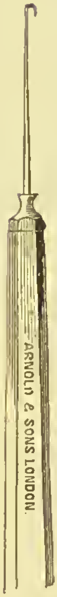

FIG. 155.

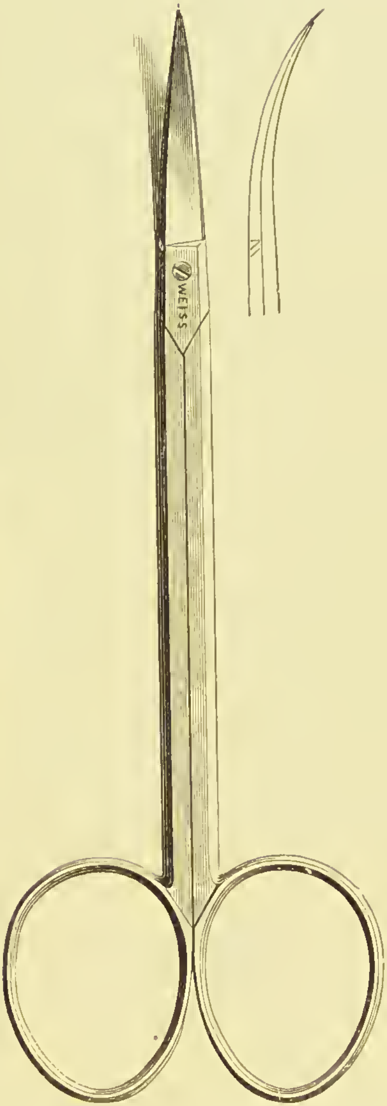

FIG. 156.

OPERATIONS ON THE IRIS.

***Iridectomy**.—This is performed for optical purposes, in zonular cataract, corneal opacities, or closed pupil; to reduce abnormally high intraocular tension, in primary and secondary glaucoma; and for the removal of tumours or foreign bodies in the iris.

The instruments required are a spring speculum; a fixation forceps, with spring catch (Fig. 157); a lance-shaped iridectomy knife (keratome) (Fig. 153), or a Græfe's cataract knife; a bent iris forceps (Fig. 154), or a Tyrrell's hook (Fig. 155); an iris scissors curved on the flat (Fig. 156), or a de Wecker's forceps-scissors; and a small spatula.

The width of the coloboma depends a good deal on the length of the corneal incision, for it cannot be wider than the incision is long. *Its depth* depends on the proximity of this incision to the corneo-scleral margin. If a wide and very peripheral coloboma be desired, the incision must be long, and must lie actually in the corneo-scleral margin; the iris forceps being then introduced, a portion of the iris corresponding to the length of the incision may be seized, drawn out, and cut off, the blades of the scissors being applied parallel, and close to the incision, and by this means a coloboma, as at Fig. 158, is produced. An incision somewhat inside the corneal margin will give a pupil, as in Fig. 159. A narrow coloboma (Fig. 160) is obtained by a

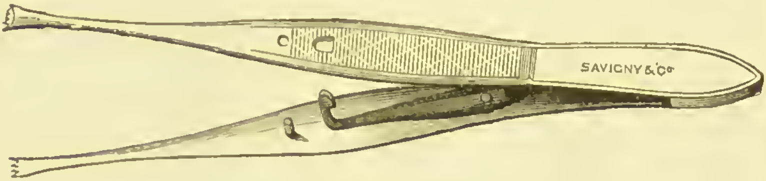

FIG. 157.

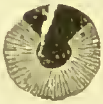

FIG. 158.

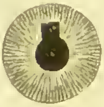

FIG. 159.

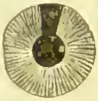

FIG. 160.

short corneal incision, which may be more or less peripheral as circumstances require; by taking up as little as possible of the iris in the forceps, or by using a Tyrrell's hook, instead of an iris forceps, for catching and drawing out the iris; and by applying the blades of the scissors at right angles to the incision in the corneal margin.

In glaucoma a wide and very peripheral coloboma is required. For optical purposes a narrow iridectomy is required, because with a wide coloboma the diffusion of light may be very troublesome to the patient.

The best position for an iridectomy for glaucoma is in the upper quadrant of the iris, as there the subsequent dazzling by light and the disfigurement are least. But the position, by preference, for an optical pupil is below and to the inside, being that most nearly in the direction of the axis of vision. If, however, this position be occupied by a corneal opacity, the coloboma should be made directly downwards; or, if that place be ineligible, then downwards and outwards, or directly downwards, or directly inwards. The upward positions are not satisfactory for optical pupils, owing to the overhanging of the upper lid; yet it often happens that we have no other choice.

In the Performance of an Iridectomy, the eye should be fixed with a forceps at a position on the same meridian as that in which the coloboma is to lie, but at the opposite side of the cornea, and close to the latter. The point of the lance-shaped knife is then to be entered almost perpendicularly to the surface of the cornea, and made to penetrate the latter. As soon as the point of the blade has entered the anterior chamber, the handle of the knife is lowered, and the blade is passed on into the anterior chamber in a plane parallel to the surface of the iris, until the incision has attained the required length. The handle of the knife is now lowered still more, so as to bring the point of the blade almost in contact with the posterior surface of the cornea, in order to prevent any injury to the lens in the next motion. The knife is then very slowly withdrawn from the anterior chamber. At the same time the aqueous humour flows off slowly, and the crystalline lens and iris come forwards. The fixation forceps is now taken over by the assistant, and the bent iris-forceps is passed closed into the anterior chamber, its points directed towards the posterior surface of the cornea, so as to avoid engaging them in the iris. When the pupillary margin has been reached, the forceps is opened as widely as the corneal incision will permit, and the corresponding portion of the iris is seized and drawn out to its full extent through the corneal incision. With the scissors held in the other hand the exposed bit of iris is snipped off quite close to the corneal incision. Care should now be taken that the angles of the coloboma do not remain in the wound; and, if they are seen to do so, they must be reposed by stroking the region of the incision with a hard rubber spoon, or by pushing them into their places gently with the spatula.

Iridotomy.—For description and uses of this operation see chap. xiv.

CHAPTER XII.

THE PUPIL.[1]

THE movements of the iris, which produce contraction and dilatation of the pupil, are governed by two unstriped muscles—namely, the sphincter pupillæ, and the dilator pupillæ. The sphincter is a ring of muscle situated close to the margin of the pupil and is supplied by the third nerve, while the dilator is a thin muscular layer, of which the fibres are arranged radially, and which is situated near the posterior surface of the iris, and is supplied by the sympathetic nerve.

As the iris muscles are not under the control of the will, they are set in motion either by reflex stimuli, or by what Parsons aptly terms synkinesis—*i.e.*, by association with other voluntary or involuntary movements.

Contraction of the Pupil is brought about by the light reflex, or by the accommodation synkinesis.

The Light Reflex depends upon the transmission of the stimulus from the retina, by the afferent path to the pupil constricting centre of the third nerve nucleus in the floor of the Aqueduct of Sylvius, and thence by the efferent third nerve path to the sphincter pupillæ. As regards the afferent path, it has been ascertained that the optic nerve contains fibres of two different calibres, and it is held that the finer fibres are afferent pupillo-constrictor, the coarser fibres being the visual fibres. The pupillary fibres undergo partial decussation in the optic commissure, and pass into the optic tracts. They leave the tract before it reaches the external geniculate body, but at what point, and their further route to the third nerve nucleus, are not certainly known. It is on the whole probable that the path taken is by the superior brachium to the superior quadrigeminal body, and thence by new connections to the third nerve nucleus of the same and of the opposite side. The portion of the third nerve nucleus which gives origin to the pupillo-constrictor fibres is the Edinger-Westphal nucleus, situated in the median part of the main nucleus.

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[1] For much of the physiological portions of this chapter the authors are indebted to Mr. J. Herbert Parsons' 'Arris and Gale Lectures,' 1904.

The efferent pupillo-constrictor path is contained in the trunk of the third nerve. In the orbit the pupillo-constricting fibres pass into the branch which supplies the inferior oblique, and leave it again by the short root of the ciliary ganglion. From this ganglion the sphincter nerve filaments—the short ciliary nerves—pass to the eyeball, pierce the sclerotic around the optic nerve, and pass on the inner surface of the sclerotic to the iris. The innervation of the ciliary muscle (the muscle of accommodation) is from the same source.

The Accommodation Synkinesis is contraction of the pupil associated with accommodation, or more strictly with convergence of the optic axes. The act of accommodation of the eye for near vision is intimately bound up with the act of convergence of the optic axis, which takes place simultaneously with accommodation (see p. 26), and it can be shown, that if, experimentally, accommodation and convergence be dissociated, it is possible to accommodate without producing contraction of the pupil, but not to converge the optic axes without that synkinesis. Hence it is really with the act of convergence, not with the act of accommodation, that contraction of the pupil is associated. The object of this contraction is to cut off rays which would fall on the peripheral portions of the lens, portions which are not curved in the change for accommodation in the same degree as is the centre of the lens.

Engorgement of the bloodvessels of the iris, as in hyperæmia, or inflammation, or following paracentesis of the anterior chamber, is a third influence which causes contraction of the pupil.

Dilatation of the Pupil.—The nerve supply of the dilator pupillæ is from the cervical sympathetic. The path originates near the third nerve nucleus, and passes through the medulla to a region, in the upper dorsal and lower cervical portion of the lateral column of the spinal cord, called the cilio-spinal centre. The path leaves the cord by the central roots of the first three thoracic nerves, and thence, by way of the rami communicantes, passes on to the first thoracic ganglion. Thence into the anterior and posterior limbs of the annulus of Vieussens and by the cervical sympathetic to the superior sympathetic ganglion, from whence the path enters the skull by the cervico-gasserian fibres to reach the gasserian ganglion. From this ganglion it passes to the ophthalmic division of the fifth nerve by its nasal branch, and then, leaving it, it joins the long ciliary nerves which enter the eye around the optic nerve, and reach the iris by passing forwards between sclerotic and chorioid. It seems probable, however, that all the dilating fibres do not run to the eye by way of the cervical sympathetic, and that the gasserian ganglion receives pupil-dilating fibres from the sympathetic traversing the cavum tympani. Dilatation of the pupil is brought about by the sensory reflex, or by the cerebral synkinesis.

The Sensory Reflex can be induced by almost any sensory stimulus

—*e.g.*, the prick of a pin or a pinch on the neck, galvanism applied to the leg, the tickling of a sensitive place in the region of the fifth nerve on the face, etc. Westphal observed dilatation on shouting loudly into the ear of a person under chloroform. Schiff and Foa found that in curarised dogs and cats a dilatation took place on the application of every stimulus, not necessarily painful, applied to the nerves of common sensation in any part of the body. Indeed, it is not necessary in the human subject that the stimulation should produce any sensation, for stimulation of the skin of the affected side in hemianæsthesia, as also in sleep and in coma, will find response in dilatation of the pupil. The afferent impulses, in the case of nerves of common sensation, reach the cilio-spinal centre by way of the posterior spinal columns.

The Cerebral Synkinesis is induced by psychical emotions. The pupils of a cat in anger dilate, and those of a frightened child. In sleep, or when under the complete influence of an anæsthetic, the pupils are contracted, for then all psychical and sensitive stimuli are reduced to a minimum. Facts authorise the conclusion that the medium dilatation of the pupil in the healthy state depends chiefly on the intensity of these stimuli, habitually transmitted through the sympathetic. If in any individual they be slight, his pupil is contracted; if intense, it is dilated. In delicate, nervous, excitable people the pupils are often much, and habitually, dilated.

In addition to those already mentioned, there are causes for the dilatation of the pupil, which can hardly be referred to simple reflex action, but which seem to be, like the contraction of the pupil on convergence of the visual lines, synkinetic with other centres in the medulla oblongata, especially with those for respiration and uterine action. With every *deep* inspiration or expiration a considerable pupillary dilatation takes place, not identical with that slight dilatation occurring on each ordinary inspiration, and depending on variation of blood pressure, but due to simultaneous stimulation of the respiratory and pupil-dilating centres by retention of carbonic acid gas in the blood. Marked dilatation at the beginning of each labour pain has been observed, and may be explained as an associated action of the neighbouring centres for uterine movements and pupil-dilatation.

Hippus. In addition to the normal pupillary motions described in the foregoing, and visible for the most part to the naked eye of the observer, there is a phenomenon of pupillary motion, termed hippus, which is discoverable only by aid of a corneal microscope or loup, consisting in perpetual, but very minute and irregular, fluctuations in size of the pupil. It is due to the ever-varying sensitive and psychical reflexes which are thus constantly manifesting their influences on the pupil.

The reflex mobility of the pupil to light is tested most commonly for the purpose of deciding the existence or otherwise of posterior synechiæ.

The next most common object of the test, is to determine the sensitiveness to light of the retina or of the visual centre. It affords generally a sufficient test of the presence or absence of quantitative perception of light: but the latter function may be wanting in certain diseased states, and yet the pupil-reflex take place; or the pupil-reflex may be wanting, and still perception of light be present. The test is best performed in diffuse daylight, with the patient's face directed towards the window, a distant object being looked at, and the eye which is not under examination being carefully excluded from the light. The surgeon then, having observed the size of the pupil to be examined, excludes the eye from light with his hand for some moments. On removing the excluding hand, a normally reacting pupil will be found to have become dilated; and this dilatation, after an interval of about half a second, will be observed to give way to an extreme contraction, which is maintained only for a moment, and is then succeeded by a moderate dilatation, and the pupil then again contracts somewhat, and so on, until, after some further minute oscillations, it comes to a standstill. The explanation for this hippus is that each contraction of the pupil, by diminishing the supply of light to the retina, contains in itself the cause of the succeeding dilatation; and. for the converse reason, each dilatation sets a-going the succeeding contraction, until at last equilibrium is attained. A comparison between the maximum of dilatation and maximum of contraction, along with the promptness and rapidity with which the contraction takes place, enables the observer to form an estimate of the activity of the pupil-reflex. In performing this test it is important that the patient's gaze should be fixed all the time on a distant object—hence, unless where a mere trace of perception of light remains, the test used with the artificial light is not so reliable as that with daylight—so that the accommodation synkenesis may not vitiate the experiment. The consensual reflex of the pupil, as well as the direct, should always be tested—one eye being alternately excluded and exposed, the motions of the pupil of the other eye are observed and compared with those of its fellow. In examining the pupils we have also to decide whether they are of equal size; and, in order to avoid error through posterior synechiæ, the comparison should be made, with both eyes open, successively in two very different brightnesses of light. Under normal conditions equality in size of the pupils will exist, not only with both eyes open, but also if one eye be shaded; for the normal consensual pupil-reflex is equal to the direct reflex. If the pupils be found of different sizes, the least movable one is usually the pathological pupil; but this question is often difficult to decide. Finally, it should be noted whether the direct pupil-reflex is similar in all respects in each eye.

Action of the Mydriatics on the Pupil. (See also p. 430.)—Solution of sulphate of atropine dropped into the conjunctival sac dilates the pupil, through absorption into the aqueous humour. For it has been shown that the aqueous humour of an eye into which atropine has been instilled acts as a mydriatic when dropped into another eye. It is evident that atropine acts, not merely by paralysing the sphincter pupillæ, but also by stimulating the dilator, inasmuch as in complete paralysis of the third nerve instillation of atropine produces a further dilatation of the pupil. If cocaine be combined with atropine in the solution, or if it be dropped in as a separate collyrium, a further dilatation of the pupil takes place. Whether this is to be referred to contraction of the blood-vessels of the iris, or to stimulation of the sympathetic supplying the dilator pupillæ, is not clear. Scopolamine, homatropine, ephedrine, etc., act similarly to atropine.

Action of the Myotics on the Pupil. (See also p. 422.)—These drugs —of which the chief are Eserine and Pilocarpine—act in all respects as the complete antagonists of the mydriatics, by stimulating the endings of the third nerve in the sphincter pupillæ. Morphia, taken internally or used hypodermically, has an antagonistic effect to atropine, when it is absorbed into the system, and is employed as an antidote in cases of atropine poisoning. (See p. 358.)

The three following tables, show the action of

TABLE

THE MYDRIATICS

	ATROPINE.	SCOPOLAMINE.
Solutions commonly used	Atropine sulphate $\frac{1}{2}$ to 2 per cent. Most commonly 1 per cent.	Scopolamine hydrobromate $\frac{1}{10}$ to $\frac{1}{4}$ per cent. (According to some it is identical with hyoscine.)
Effect on pupil	Almost maximum mydriasis; light reaction lost; increased by cocaine.	Same as atropine.
Effect on accommodation	Complete cycloplegia; begins later than mydriasis.	Same as atropine.
Action—		
begins in	10 to 15 minutes.	7 to 10 minutes.
reaches maximum in ...	15 to 20 minutes.	25 minutes.
lasts from	6 to 10 days.	4 to 7 days.
Effect on tension	Doubtful in normal eyes; increases tension in eyes predisposed to glaucoma.	Doubtful; tension not increased according to Raehlmann.
Remarks	Atropine possesses some *disadvantages*, viz.: (*a*) Absorption through lacrimal passages, causing poisonous symptoms (dryness and redness of throat and face, faintness, staggering, delirium). (*b*) Atropine infiltration, redness and swelling of eyelids and cheek. (*c*) Follicular conjunctivitis from frequent application. On account of its *strong* and *lasting* action it is the *best mydriatic for protracted use, as in iritis.*	Scopolamine is five times as powerful as atropine, but its effect is of shorter duration. In $\frac{1}{4}$ per cent. solution it is not more poisonous than atropine, and less so than duboisine. It is better borne by the conjunctiva than atropine. It should be used, therefore— (*a*) *Where atropine is not strong enough to break down posterior synechiæ.* (*b*) *Where atropine infiltration occurs.*

A few drugs not included in this table have been and are still used. Of these and are not to be recommended. Cocaine as a mydriatic is not very useful when Holocaine acts in the same way, without, however, affecting the cornea or circu-

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[1] These tables have been drawn up chiefly by the aid of a paper by Dr. H. Schultz, *Archiv für Augen*

e various mydriatics, myotics, and local anæsthetics.

(Pupil Dilators).

Homatropine.	Ephedrine.	Mydrine.	Euphthalmine.
om atropine hydrobro mate 1 per cent.	10 per cent.	A mixture of homatropine and ephedrine : Homatropine 0·01 Ephedrine . 1 Water . . 10	Euphthalmine hydrochlorate 5 per cent.
od mydriasis, but ess than atropine.	Good mydriasis; light reaction retained.	Mydriasis greater than either constituent; light reaction feeble.	Maximum mydriasis; light reaction lost.
rked, but not complete cycloplegia.	Little or no effect.	None.	Less than homatropine.
to 15 minutes. minutes. to 24 hours.	8½ minutes. 30 to 60 minutes. 5 to 20 hours.	8½ minutes. 30 to 40 minutes. 4 to 6 hours.	10 to 15 minutes. 60 to 80 minutes. 5 to 7 hours.
t so liable to raise ension as atropine.	Little or none.		None.
matropine is less owerful and less oisonous than atroine. On account of s action on accom- odation, and the hort duration of its ffect, it is the *best ydriatic for esti- ating errors of re- raction.* Its effect increased by the ddition of cocaine.	It does not act quickly enough for use in practice as an aid to ophthalmoscopic diagnosis, and is more useful when combined with homatropine.	The mydriasis being greater and of shorter duration than with either constituent, and having no action on the accommodation, it is well *suited for ophthalmoscopic diagnosis.*	Although a little slower than homatropine, it is as good a mydriatic, but has the advantage of acting on the accommodation in only a slight degree, and its effects pass off much more quickly. It is also more powerful than mydrine, and therefore *the best mydriatic for ophthalmoscopic diagnosis.* It possesses no irritating or toxic effects, and does not injure the corneal epithelium.

rine is the same as atropine. Hyoscyanine and duboisine are very active poisons, loyed alone, but it facilitates absorption, and increases the effect of other mydriatics. n, like cocaine.

älteren und neuern Mydriatica, Miotica und Anästhetica in der Augenheilkunde," Bd. xl., s 125.

TABLE II.

MYOTICS (PUPIL CONTRACTORS).

	ESERINE SULPHATE.	PILOCARPINE HYDROCHLORATE.	ARECOLINE HYDROBROMATE.
Strength of solution commonly used	½ to 1 per cent (the former less irritating).	1 to 5 per cent.	1 per cent.
Effect on pupil	Strong contraction of sphincter pupillæ, reducing pupil to pinhole size.	Same as eserine, but weaker.	The same as eserine.
Effect on accommodation...	Spasm of ciliary muscle adapting eye for near point.	The same properties as eserine, but weaker.	The same as eserine.
Action— begins in ... ... reaches maximum in ... lasts from	 1 to 1½ minutes. 30 to 40 minutes. 24 to 36 hours.	The same as eserine.	It acts more quickly and more powerfully than eserine, but its effects pass off very rapidly (1½ hours).
Effect on tension	It reduces the tension in glaucomatous conditions.	The same as eserine.	The same as eserine.
Remarks	When instilled into the eye it at first causes twitching of the eyelids and sometimes severe supraorbital pain, due to spasm of accommodation. It is chiefly used for the reduction of abnormally high tension. It is also used in peripheral corneal ulcers, and after cataract extractions to prevent prolapse of the iris. In some eyes, especially if hyperæmic, it is liable to cause slight iritis. The fresh solution is white, but soon becomes red, without, however, losing its efficacy.	Is not so liable as eserine to cause iritis.	Is obtained from the areca-nut. It may be of use in some cases in which eserine fails to act.

TABLE III.—LOCAL ANÆSTHETICS USED IN OPHTHALMOLOGY.

	COCAINE HYDROCHLORATE.	TROPA-COCAINE.	EUCAINE B.	HOLOCAINE.
1. *Strength* solution in use	2 to 4 per cent.	3 % (in 0·6 % NaCl, to prevent irritation).	2 per cent.	1 per cent.
2. *Anæsthesia* begins in	2 to 3 minutes.	$\frac{1}{2}$ to 2 minutes.	2 to 5 minutes.	$\frac{1}{2}$ to 1 minute.
3. Effect on *pupil* and *accommodation* ...	Transient mydriasis and cycloplegia.	None.	None.	None.
4. Effect on *cornea* ...	Tends to produce dryness and exfoliation of epithelium.	None.	Same as cocaine, but in a less degree.	Same as cocaine, in a slight degree.
5. Effect on *intraocular tension*	In normal eyes sometimes lowers tension, but raises it in eyes predisposed to glaucoma.	None.	None.	None.
6. Other effects	Causes slight smarting, followed by anæmia and cold sensation, and occasionally marked retraction of eyelids.	Slight burning; no anæmia.	Smarts more than cocaine, and causes hyperæmia. (Eucaine A is too irritating for use.)	Slight smarting and slight hyperæmia.
7. Remarks	Cocaine as a local anæsthetic possesses some *disadvantages*. It does not act well in inflamed eyes. Its effects under heads 3, 4, and 5 are undesirable. Instillations rarely cause toxic symptoms, but the latter may occur after subconjunctival injection even of three-quarters of a grain. It is stated that cocaine decomposes on boiling, and loses its effect; but we have repeatedly sterilised the same solution without any marked diminution in its action. It seems, however, to render the solution more irritating.	Acts more rapidly and more powerfully than cocaine; is very stable and only half as poisonous.	Less poisonous and more stable than cocaine, but is more irritating, especially in inflamed eyes.	More powerful and efficient than the other anæsthetics. Can be sterilised without decomposition. Is an antiseptic. *It should not be used for subconjunctival injection or for lacrimal passages*, as it is more poisonous than cocaine, resembling strychnia in its action.

It will be seen from the above that holocaine is the best anæsthetic for all purposes, except subconjunctival injection and treatment of the lacrimal passages. Some surgeons have derived benefit from it in the treatment of corneal ulcers, owing to its antiseptic properties. Several other local anæsthetics (acoine, strophantine, alypine, etc.) have been tried, but they have proved either inferior or too irritating.

CHAPTER XIII.

GLAUCOMA.[1]

The chief and essential symptom of this disease is Increased Intraocular Tension—increased hardness of the eyeball—due to over-fulness of the globe.

There is Primary Glaucoma and Secondary Glaucoma.

In primary glaucoma, the increased tension comes on without any previous recognisable disease of the eye; and it is with it we have mainly to do in this chapter.

In secondary glaucoma, the increased tension comes on in consequence of obvious antecedent disease in the eye.

PRIMARY GLAUCOMA.

Primary glaucoma is almost invariably a binocular disease; although it does not always attack each eye simultaneously, indeed it is more common for the disease to appear in the eyes with an interval of months, or longer.

Of primary glaucoma there are two great kinds—Chronic Simple Glaucoma; and Congestive, or more or less Acute Glaucoma. There is also Chronic Congestive Glaucoma.

Increased intraocular tension, as stated, is the chief and essential symptom of glaucoma, whatever form of it may come before us; although this increased tension may not always be present in the same degree, or at every time.

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[1] From γλαῦκος, *sea-green*. The name was given to the disease by the old writers, on account of the greenish reflection obtained from the pupil in some cases. But this greenish reflection is seen in other diseased conditions, and therefore is not characteristic of glaucoma.

If the tips of the index fingers be placed close together on a normal eyeball (Fig. 161), and gentle pressure made with them alternately, it will be observed that the eyeball pits slightly on this pressure, and that a sensation of fluctuation is given to the fingers. The amount of this fluctuation varies according to the degree to which the eyeball is filled with its humours, and also, to some extent, according to the thickness of the sclerotic coat. The glaucomatous eyeball is more resistant—is harder—than the normal globe.

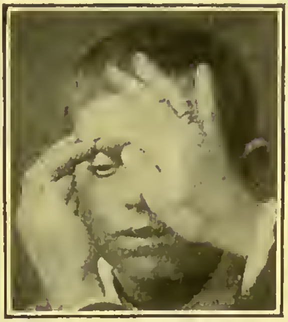
FIG. 161.

But there are normal eyes which have a tension below the average normal tension, and others which have a tension somewhat above the average normal tension; and, in eyes of the latter class, it is occasionally difficult to decide whether or not the tension be abnormally high. If it be a question of one eye only, then a comparison of its tension with that of its fellow decides the question, for the physiological tension is always the same in each eye.

While marked variations from the normal are easily observed, some clinical experience is necessary in order to appreciate by palpation those degrees of tension which are just above or just below the normal; and no other method is equally satisfactory. Tonometers have indeed been invented and employed, but for clinical purposes the educated fingers, used as above described, are to be preferred.

For the purposes of clinical notation certain signs have been adopted. Normal tension is indicated by the letter T, slight increase of tension by T + 1, still higher tension by T + 2, while T + 3 indicates stony hardness of the eyeball. In the same way diminished tension is T − 1, T − 2, and T − 3. T + ? and T − ? indicate that it is doubtful whether the tension be slightly above or below the normal.

The other symptoms of glaucoma are largely due to the increased tension; but in chronic glaucoma there are by no means so many symptoms as in acute glaucoma. Let us now discuss these two great forms of primary glaucoma separately.

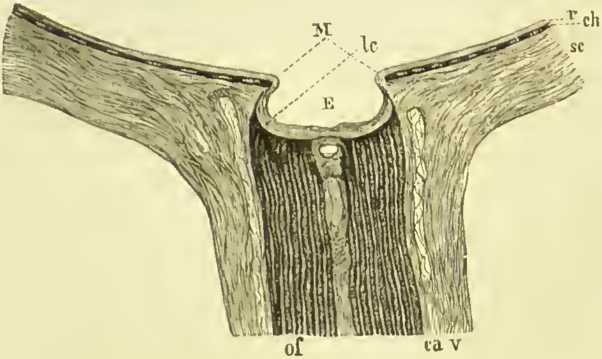

FIG. 162.—(*Ed. Jaeger*), sc, Sclerotic; ch, Chorioid; r, Retina; of, Optic nerve; ca, Intervaginal space; v, External sheath of the optic nerve; E, Excavation of the papilla; M, Margin of the excavation; lc, Lamina cribrosa.

And first as to **Chronic Simple Glaucoma,** (also known as Simple Glaucoma, and as Chronic Non-Congestive Glaucoma).

Symptoms.—The tension is raised. Sometimes the eye is very hard (T + 2, or more), and again it may be but slightly raised (T + 1). Even in one and the same eye the tension usually varies, and may be at one time too high, and at another almost, or quite, normal.

The external appearance of the eye is usually normal, and the pupil reacts well to light. The anterior chamber is sometimes a little too shallow.

On examination with the ophthalmoscope, the optic papilla is found to be cupped. The optic disc, being the weakest part of the ocular wall, is the first place to give way to high intraocular tension; and after a time it becomes depressed or cupped, the lamina cribrosa being pushed back (*E*, Fig. 162), the cup being sometimes deeper than the outer surface of the sclerotic. This cupping of the papilla is a most important sign of glaucoma, and differs essentially in appearance from the physiological cupping (*vide* p. 122), inasmuch as it occupies the entire area of the papilla, and has steep, not shelving, sides. As shown in Fig. 162, the walls of the excavation are often hollowed out, and the ophthalmoscopic effect of this is to give to the retinal vessels the appearance of being broken off at the margin of the papilla (Fig. 163), where they pass round the overhanging edge of the excavation, and become hidden by it, while on the floor of the excavation they reappear.

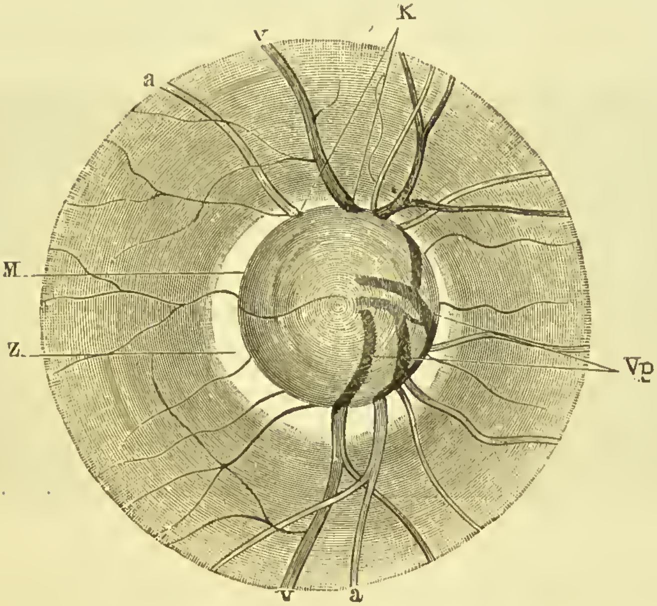

FIG. 163.—(*Ed. Jaeger*), a, Arteries; v, Veins; M, Margin of disc; K, Bending of vessels at margin of the disc; Vp, Vessels on the floor of the excavation; z, Glaucomatous ring.

The presence of an excavation may be recognised ophthalmoscopically, in the examination by the indirect method, by means of lateral motions of the convex lens. It will be then seen that, while the whole fundus seems to move along with the motion of the lens, the floor of the excavation apparently moves in the same direction, but at a slower rate. This parallax is the more marked the deeper the excavation. The phenomenon is explained by the accompanying figure (Fig. 164). If *o* be the optical centre of the lens being used in the examination, and *b* and *a* two points lying one behind the other, the inverted images of these points will be situated at *b′* and *a′*. The line *a′ b′* lies in the visual line of the observer; and if the lens be moved upward a very little, so that the optical centre comes to *o′*, the inverted images of *b* and *a* will be removed to b^2 and a^2. If the observer have not altered his point of view, it will seem to him that the point *b* has made a more extensive motion than the point *a*; or that it has moved more rapidly than *a*, and has glided between *a* and the observer. Short and rapid motions of the lens from side to side, or from above downwards, will best show the parallax.

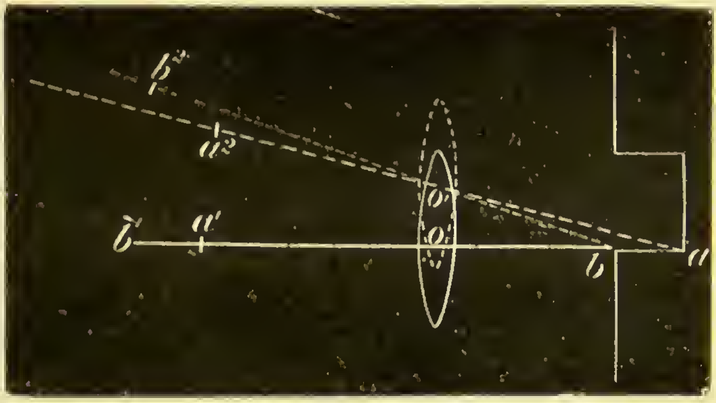

FIG. 164.

In the upright image, the existence of an excavation may be ascertained, by observing that a lens of a different power is required in order to obtain a clear image of the margin of the papilla and of its floor. The depth of the excavation may be estimated by noting the difference between these two lenses—*e.g.*, if the general fundus of the patient be emmetropic, and the emmetropic observer require −3 D to see the floor of the excavation, the depth of the latter is about 1 mm., and in the same proportion up to 10 D.

Besides being cupped, the optic papilla in glaucoma becomes atrophied from the pressure, and its consequent pallor serves to aid the diagnosis between this and a physiological excavation.

Spontaneous pulsation of the arteries on the optic papilla may be often noted in glaucoma, or can be produced by slight pressure with the finger; because blood can only be forced into these vessels by a pressure greater than that opposed to it. In the eye with normal tension there is no arterial pulsation,—and slight pressure with the tip of the finger would not bring it on,—for the tension of the coats of the vessels is greater than the intraocular tension; and therefore the blood passes on in a continuous stream. But, in the decidedly glaucomatous eye, the intraocular tension opposes so great an obstacle to the arterial flow, that at the systole alone can it make its way through.

Arterial pulsation also occurs, although rarely, in exophthalmic goitre (see chap. xix.); and it occurs where the pressure in the arteries themselves is low (weak heart's action, aortic regurgitation, etc.), although that in the vitreous chamber be normal.

Around the margin of the glaucomatous excavation, especially in chronic glaucoma, one usually sees the whitish appearance, termed the glaucomatous ring (Fig. 163), which is held to be due to atrophy of the chorioid from pressure.

Increasing dimness of sight is the only symptom of which the patient complains in chronic simple glaucoma.

An examination of the field of vision will show it to be contracted, in consequence of interruption to conduction in the retinal nerve-fibres from pressure on them at the margin of the depressed optic papilla. This contraction of the field must always be carefully looked for with the perimeter in eight or ten meridians, as it is most important for diagnosis and prognosis. The contraction commences at the nasal side as a rule, while at the same time central vision is lowered, and later on the temporal portion of the field becomes contracted, and gradually complete blindness is brought about.

In addition to the perimetric examination of the field, Bjerrum recommends that it should be investigated further by aid of a black velvet screen two metres square, and a small test object. By this means the state of relative vision within the field is examined. In glaucoma he finds the area of relative defect in the field can always be traced to the blind spot, if a sufficiently small test-object be used; or, in other words, that the area of most acute vision, and that of relative defect, meet at the blind spot.

Cases are met with in which the optic disc is cupped and pale, and in which increased tension is either not present at the time of the examination, or is so slight as to be doubtful. And here the diagnosis between glaucoma, and primary atrophy of the optic nerve with cupping of the disc, may be exceedingly difficult. The examination of the field of vision by the ordinary method does not always assist, for in each of these diseases it is liable to be contracted; but if the contraction occur with re-entering angles, it points to primary atrophy, for this form of field is not found with glaucoma. Bjerrum's symptom (*vide supra*) can come to aid here. The effect of a myotic on the intraocular pressure may aid the diagnosis, for it would not materially influence normal tension, while it would reduce abnormally high tension.

The colour sense usually remains normal in glaucoma until a late stage, while in primary optic atrophy it is defective at an early stage. Again, if slight pressure with the tip of the surgeon's finger produce arterial pulsation at the optic papilla, it is suggestive of glaucoma, for in a normal eye considerable pressure is needed to produce this effect.

The progress of chronic simple glaucoma is extremely slow and insidious, extending often over several years, and ending in total blindness, if untreated. It usually attacks both eyes, but generally one of them long before its fellow. Sometimes chronic simple glaucoma, after a time, takes on the acute or the sub-acute form.

Acute Glaucoma. (Also called Acute Congestive Glaucoma.)—In this form, the increase of tension is always very marked. In addition there are the following symptoms:—

Diminished Depth of the Anterior Chamber, from pushing forwards of the lens and iris.

Diminution of the Refracting Power of the Eye, by reason of the nearer approach of the latter to a globular shape.

Diminution of the Amplitude of Accommodation, and Anæsthesia of the Cornea, owing to pressure on the ciliary nerves as they pass along the inner surface of the sclerotic.

Opacity of the Cornea, giving its surface a peculiar steamy or breathed-on appearance, due to œdema of the corneal tissue and epithelium, by infiltration into them of the intraocular fluids from high tension. A similar appearance, although brought about in a different manner, is sometimes seen in iritis and iridochorioiditis, and in interstitial keratitis.

Indistinctness of the Pattern of the Iris, similarly due to œdema.

Opacity of the Aqueous and Vitreous Humours.

Dilatation and Immobility of the Pupil, the result, according to some, of paralysis of the ciliary nerves, but, according to others, of anæmia of the iris from pressure on its vessels. The pupil is oval, with its long axis vertical.

The Episcleral Veins are large and tortuous, owing to the pressure on the vasæ vorticosæ preventing the discharge by those channels of the chorioidal venous blood, which must then pass off by the anterior ciliary veins.

Subjective Appearances of Light and Colour, and coloured halos or rainbows around lamps and candles (iridescent vision), are complained of.

Pain is a very marked symptom of acute glaucoma, both in the eye, and radiating over the corresponding side of the head, and is often very violent.

Vision is greatly affected, and the field of vision, when it can be examined, will be found contracted, in cases of some standing.

The Optic Papilla, when the media are sufficiently clear to admit of its being examined, is seen to be cupped, if the disease have continued sufficiently long to bring about this change.

In acute glaucoma we recognise certain *Premonitory Symptoms*—viz., sudden diminution of the amplitude of accommodation, evidenced by the rapid onset or increase of presbyopia, and the consequent necessity for higher + glasses for near work ; and the occasional appearance of coloured halos around the flames of lamps or candles, with attacks of fogginess of the general vision. The duration of one of these foggy attacks may be from a few minutes to several hours. Such attacks are apt to occur after a sleepless night, or after a meal, and are sometimes accompanied by peri-orbital pains. Slight opacity of the aqueous humour, and sluggishness of the pupil, with some dilatation, are present during an attack ; but the eye afterwards returns to its normal condition, and remains so for weeks or months, until another similar attack comes on. Such a premonitory stage may last a year or longer, but cases also occur in which there is no premonitory stage.

The most favourable time for operative interference is during this premonitory stage. The operation can then be performed with technical accuracy in an eye free from congestion, and with a normally deep anterior chamber. There is, too, as yet no loss of sight, nor any degeneration of the tissues of the eyeball. The difficulty is to induce patients to consent to operation at this period.

The onset of the *True Glaucomatous Attack* is usually at night. It is accompanied by violent pain radiating through the head from the eye, and by pericorneal injection, chemosis, and lacrimation. The aqueous humour becomes cloudy, the anterior chamber shallow, the iris discoloured, and the pupil dilated to medium size and of oval shape, while the cornea becomes steamy and anæsthetic. The patient frequently complains of subjective sensations of light, and vision is very defective, or may be quite wanting. Vomiting very frequently accompanies acute glaucoma, and has often led to errors of diagnosis, the patient's ailment having been taken to be a gastric disease, while the ocular symptoms were regarded as mere coincidences, such as a cold in the eye, neuralgia, etc.

An attack such as that just described may, to a great extent, pass away in the course of a few days, but a complete remission of all the symptoms does not again take place. Some defect of central vision is left, or, it may be, some slight peripheral defect in the field of vision; the tension does not become quite normal again, and the pupillary motions remain slightly sluggish. Another acute attack of glaucoma comes on in the course of some weeks or months, and it, too, may pass away, leaving the eye in a still worse condition than it found it. The attacks gradually become more frequent; and if in the intervals the eye be examined, the cornea and vitreous humour will be found more or less opaque, the optic papilla cupped, and pulsation of the central artery of the retina may be discovered. Finally, there is no remission from the attack, the violent glaucomatous symptoms become permanent, and all vision is for ever destroyed.

Even when vision has been destroyed, the high tension continues, and gradually produces that disorganisation of the tissues of the eyeball known as glaucomatous degeneration. The iris becomes atrophied, the lens becomes opaque, and the cornea frequently ulcerates, while hæmorrhages are apt to occur in the anterior chamber. In time the excessive intraocular tension causes staphylomatous bulging of the sclerotic in the ciliary region, or further back; and, finally, such eyes may become the subjects of acute purulent chorioiditis, and end in phthisis bulbi.

Acute glaucoma almost always comes on in both eyes, either at the same time, or with an interval, it may be of weeks, or of months.

The reason for the marked difference between the symptoms and course of chronic and of acute glaucoma is, probably, that in the former the increase of tension is very gradual, and therefore the eye gradually becomes accustomed to it; while in acute glaucoma the increase is rapid or sudden, and the circulation of the eye has not time to accommodate itself to the new state of things.

Glaucoma Fulminans is the term given to a form of the disease, which is more acute than the ordinary acute glaucoma just described. It has no premonitory stage, and, coming on with all the symptoms of acute glaucoma greatly intensified, does not remit, and causes complete permanent destruction of vision in the course of a few hours. It is a very rare form.

Subacute Glaucoma.—This form differs from acute glaucoma, in that its premonitory stage merges gradually into the actual disease, without the occurrence of an acute attack. The eye gradually becomes hard, the pupil dilated, the anterior chamber shallow, the aqueous humour opaque; while the cornea is "steamy" and anæsthetic, and the episcleral veins are distended. With the ophthalmoscope the cupped disc and pulsating arteries may be seen, when the opacities of the media permit. Vision sinks, and the field is contracted towards its nasal side. The progress of the disease is very slow; and in its course attacks of ciliary neuralgia, with greater increase of the tension, greater opacity of the aqueous humour, increase of the corneal opacity and anæsthesia, and increased dimness of vision, are experienced. These attacks pass off in the course of a few days or hours, leaving the eye harder and blinder than before. The subacute glaucoma sometimes takes on the acute form. It is liable

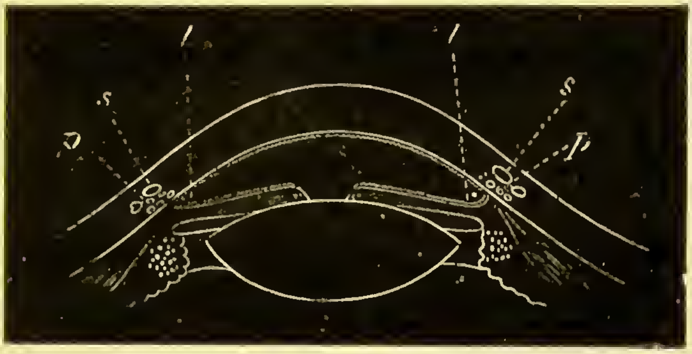

FIG. 165.—Diagrammatic representation of normal condition. *l*. Angle of anterior chamber, and ligamentum pectinatum. *s*. Canal of Schlemm. *p*. Venous plexus of Leber.

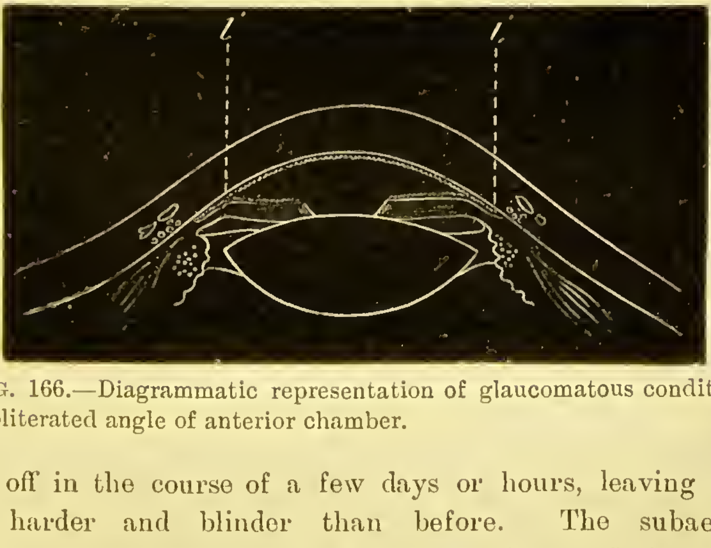

FIG. 166.—Diagrammatic representation of glaucomatous condition. *l'*. Obliterated angle of anterior chamber.

to bring about the same glaucomatous degeneration of the eye as does the latter.

Etiology of Glaucoma.—Glaucoma is a disease of advanced life, occurring most usually after fifty years of age, and rarely under the thirtieth year.

Anxiety, sorrow, and influences in general which depress the spirits have often been noticed to precede the onset of acute glaucoma, but no other immediate causes have been recognised.

Pathology of Glaucoma.—The theory of the disease which obtains the most acceptation is the retention theory. It has been ascertained that, in glaucomatous eyes, the periphery of the iris lies in contact with the periphery of the cornea (Figs. 165 and 166), and, consequently, obliterates the spaces of Fontana in the angle of the anterior chamber, to which point, the effete intraocular fluids normally flow through the pupil from the posterior part of the aqueous humour. The intraocular fluids in the normal eye largely make their exit from the eye into the sinus venosus, or canal of Schlemm. The spaces of Fontana and the canal of Schlemm are separated from each other by delicate walls consisting of a layer of endothelium merely, and hence the most favourable anatomical conditions for filtration are provided. Moreover, the intimate union of the distal aspect of the blood-vessel with the tissue of the sclerotic keeps it constantly patent, and in this way the constant outflow of the fluids is assured. Physiological experiment, too, has shown, that the intraocular fluids escape by this path. The aqueous humour, and other fluids, escape also through the veins on the anterior surface of the iris, and through the veins of the ciliary body, into the venæ-vorticosæ; but it is almost certain that the main exit is through the canal of Schlemm. Priestley Smith holds that the chief predisposing cause of primary glaucoma is an insufficient space—the circumlental space—between the margin of the lens and the structures which surround it, and he attributes the greater liability of elderly people to glaucoma, to the progressive increase in the size of the lens, which he has shown to occur as life advances. In eyes in which the circumlental space is insufficient, by reason either of the original structure of the eye—and small eyeballs are specially liable to primary glaucoma, a fact often demonstrated by the small size of the cornea in the eyes attacked—or of the enlargement of the lens, any condition which tends to overfill the veins of the head and uveal tract may initiate an attack of acute glaucoma, as follows :—An increase in the amount of blood in the uveal tract must be compensated by the expulsion of some other fluid from the eye ; consequently, the aqueous humour filters out more rapidly than is normal at the angle of the anterior chamber. As the contents of the chamber diminish, the lens and iris move forwards towards the cornea. Now, in the normal eye, and especially in the youthful eye, this compensation is effected without danger to the angle of the anterior chamber, because the lens is comparatively small, the circumlental space large, and the anterior chamber deep. But, when the lens and ciliary processes are already in close relation to each other, and the anterior chamber is already shallow, then any increased fulness of the uveal tract involves danger to the angle of the chamber. The turgid ciliary processes find insufficient space for their expansion ; they are carried forwards together with the lens, and, pressing upon the base of the iris, lock up the angle of the anterior chamber. Thereupon, the further escape of fluid being impossible, high tension of the eyeball is established. According to this explanation, then, the high tension is due to impeded escape of the intraocular fluid (the retention theory), and depends, primarily, upon an increase in the amount of blood in the eye. Priestley Smith considers that, in chronic simple glaucoma, the predisposing causes are the same as in acute glaucoma; but that in the former, the vascular disturbance being gradual and slight, the vessels adapt themselves to the slowly increasing pressure, and the angle of the anterior chamber is more or less compressed, but not tightly closed.

Treatment.—The performance of an iridectomy is the means discovered by von Græfe, in the year 1857, for the cure of glaucoma, a disease which had hitherto been incurable. This measure held for many years an undisputed position as the remedy for the disease, and has not suffered much from the competition of the operation of sclerotomy.

To ensure the success of an iridectomy for glaucoma, so far as possible, it is necessary (1) that the incision should be peripheral—*i.e.*, as far back in the corneo-sclerotic margin as is compatible with the introduction of the knife into the anterior chamber, and with the avoidance of injury to the ciliary body; (2) that the portion of iris removed should be wide—*i.e.*, involving about one-fifth of the circumference of the iris (see Fig. 158); and (3) that it should be abscised as close to the root of the iris as possible.

It is, moreover, important to withdraw the knife very slowly from the anterior chamber, when the corneo-scleral section is complete, in order that the aqueous humour may flow off gradually, lest an intraocular hæmorrhage from the sudden reduction of tension should occur. The portion of iris should be most carefully abscised, so that no tag of it may remain in the wound, and become caught in the cicatrix in the course of healing. Such an occurrence is apt to produce a cystoid cicatrix, which may at a later period become the starting-point of irritation, and even of serious inflammation. Some operators prefer von Græfe's cataract knife for the performance of the operation, but the ordinary lance-shaped iridectomy knife is the instrument usually employed. For the purpose of reducing the intraocular tension, it matters nothing what region of the iris be abscised; but, as a rule, the upper quadrant is to be preferred, for there the resulting coloboma, being covered to a great extent by the upper lid, will give rise to less diffusion of light than in any other position.

Immediately after the operation, palpation of the eyeball should show a marked diminution of tension. When this is not so the prognosis is unfavourable. Should an increase of tension occur on the day after the operation, it is of no consequence, as it passes off again in the course of the next few days. Until then, the anterior chamber will not be restored, and we see cases where the anterior chamber does not appear for a week or more. The bandage should be worn until the anterior chamber is completely restored. It is desirable to perform the operation with general anæsthesia, to secure technical accuracy. The pain for some time after the operation is considerable, and should be relieved by a hypodermic injection of morphia in the corresponding temple.

Very occasionally, immediately after iridectomy, although the operation may have been faultlessly performed, the case takes what is termed a malignant course. In these cases the lens seems to be violently pushed forwards, blocking the wound, obliterating the angle of the anterior chamber, and preventing any fluid from escaping from the eye, so that soon it is as hard, or harder, than before. This complication seems to be caused by the retention of fluid behind the lens, and is more likely to occur in cases of chronic simple glaucoma, than in the acute forms of the disease.

The only prospect of saving eyes which take on this malignant course is by means of the operation of *Posterior Sclerotomy*. A broad needle, or a Græfe's knife, is entered through the sclerotic, 8 or 10 mm. behind the outer margin of the cornea, and the blade is given a quarter turn on its axis, so as to make the wound gape, or the latter may even be somewhat enlarged in a meridianal direction. At the same time gentle pressure is applied, by means of the upper lid, on the centre of the cornea. This causes fluid to escape through the scleral wound by the side of the knife, and it also causes the lens to go back into its place, with restoration of the anterior chamber. The pressure on the cornea may be maintained with advantage for a minute or somewhat longer. This proceeding has also been suggested as a cure for glaucoma, but has not yet been put into practice. It is probable that it would only temporarily reduce the intraocular tension. Posterior sclerotomy is sometimes performed to facilitate the operation of iridectomy, in those cases of acute glaucoma where there is no anterior chamber.

As a rule, the more acute the form of glaucoma, and the earlier in the disease the iridectomy be performed, the more favourable is the prognosis in respect of the result which may be expected. The saving of normal vision can only be looked for in those cases, where it has as yet fallen but little, or not at all, below the normal, and where the contraction of the field has barely commenced. When the disease has interfered seriously with vision (of course we do not refer here to the enormous loss of sight immediately attendant upon an attack of acute glaucoma, for this is usually restored,) more than retention of the *status in quo* cannot be looked for. And even in this respect our prognosis must be most guarded, especially in chronic simple glaucoma, when the disease has advanced so far, that the contraction of the field is found to have approached close to the fixation-point, although central vision may still be fairly good. Because in such cases, while the iridectomy may prove successful in so far as reduction of tension is concerned, yet the contraction of the field—*i.e.*, the progress of the atrophy of the optic nerve—is often not arrested, and shortly afterwards may be found to engulf the centre of vision. Indeed, where the contraction is near the fixation-point at one side, and is advanced in other directions, it is better not to operate.

In general, while the results obtained from iridectomy in acute and subacute glaucoma, on the bases above laid down, can be regarded as satisfactory; in chronic simple glaucoma, iridectomy does not act with the same degree of certainty. Indeed, it is only in a small proportion of the cases of simple glaucoma that sight is saved by iridectomy. In some cases, although for some time after the operation the tension is normal, yet later on it again becomes high, and vision continues to fall, and the field becomes more contracted.

Some falling away in vision must be expected in almost all cases of chronic simple glaucoma for a time after the iridectomy; but in the favourable cases this is only temporary, and the sight gradually returns to its previous state, in the course of some weeks.

Although then, the prospects of retention of sight by means of an iridectomy are far from good, yet, as holding out the only prospect of retention of any vision, it should be recommended to the patient—except in very advanced cases—at as early a period in the disease as possible, before the field has become much contracted.

When, as is often the case, the patient comes with one eye far advanced in the disease, and the other in an early stage, it is a question which eye should be first operated on. Probably most surgeons operate on the worst eye first, with the result that the measure having been applied too late, the result is unsatisfactory, and the patient declines to allow the better eye, which might be saved, to be operated on.

In such cases the iridectomy should be made on the better eye first.

In cases of acute or subacute glaucoma it has frequently been observed that shortly, even within a few hours, after the performance of the iridectomy, the other eye, previously healthy, or, at most, affected with but slight premonitory symptoms, is attacked with glaucoma. It is probable that this is due to dilatation of the pupil, with pressing of the iris into the angle of the anterior chamber, in consequence of confinement in the dark room, and eserine should be put into the sound eye as a precaution.

It may here again (*vide* p. 359) be stated that the use of atropine, or of any other mydriatic, in an eye with a tendency to glaucoma is liable to bring on an acute attack of the disease, and must be carefully avoided in such cases.

If the tension be not relieved by the iridectomy, a supplemental iridectomy may be performed after a time, at the opposite side of the pupil from the first coloboma.

The Mode of Action of the Operation is not clearly known. The view is held that the cure depends, not on the removal of the portion of iris, but on the incision in the corneo-sclerotic margin, or, rather, on the nature of the cicatrix (filtration cicatrix) resulting from that incision. It is believed that this cicatrix is formed of tissue, which admits of a certain amount of filtration through it of the intraocular fluids, and that in this way the intraocular tension is kept down to the normal standard.

Priestley Smith has satisfied himself that, in a large number of successful iridectomies, the success is due to a permanent corneo-scleral fistula—not merely a filtration cicatrix—having been formed. The same view is held by Treacher Collins, who finds that this permanent gap is maintained by prolapse of a fold of iris into the wound. The latter author, indeed, discards the filtration-cicatrix theory, for which he considers there is no evidence. In those cases where a fistula, as described, is not formed by the operation, Treacher Collins considers that the obstruction becomes freed, either by the iris being torn away at its thinnest part—that is, its extreme root—thus leaving a large portion of the filtration angle open for drainage; or, by the escape of the aqueous and the drag on the iris, incidental to the iridectomy, being sufficient to dislodge the periphery of an iris, which has only recently come into apposition with the cornea.

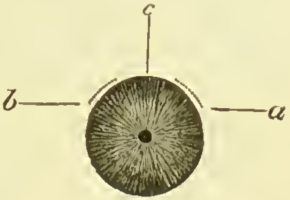

FIG. 167.

Sclerotomy.—From the point of view of the filtration-cicatrix theory, this operation was devised as a method for relief of glaucoma without iridectomy. It is employed mainly in chronic simple glaucoma—a form in which, as has been stated, iridectomy is less satisfactory than in acute or subacute glaucoma. Care must be taken that the pupil is contracted to pinhole size, or nearly so, when the operation is about to be performed, as otherwise the danger of prolapse of the iris is very great. In those cases where eserine will not produce a sufficient myosis, sclerotomy should not be performed.

The instrument used for performing the operation is von Græfe's cataract knife. A speculum having been applied, and the eyeball fixed, the point of the knife is entered into the anterior chamber, through the corneo-sclerotic margin, at a point of its circumference corresponding to that selected for the puncture in cataract extraction, but 1 mm. removed from the corneal margin, as represented at *a* in Fig. 167. The counter-puncture is made at a point (*b*) corresponding to this, at the other side of the anterior chamber. With a slow sawing motion of the knife the section is enlarged upwards, until only a bridge of tissue, about 3 mm. broad, remains (at *c*), and this is left undivided, the better to guard against prolapse of the iris. The knife is now slowly withdrawn from the eye, care having been first taken that the aqueous humour is thoroughly evacuated, which can be effected by tilting the edge of the knife slightly forwards, so as to make the lips of the wound gape somewhat. If the pupil be quite round at the conclusion of the operation, the bandage may be applied, a drop of solution of eserine having been first instilled; but if the pupil be oval, or of other irregular shape, a tendency to prolapse of the iris is indicated, and the hard rubber or silver spatula should be introduced into the anterior chamber, to restore the pupil to its normal shape by gentle pushing of the iris. If there be an actual prolapse of the iris, an attempt may be made to repose it with the spatula; but should this not prove satisfactory the prolapse is to be abscised with scissors, thus turning the sclerotomy into an iridectomy.

Although the operation has not gained many adherents, yet there are some who regard it as of great value in the earlier stages of chronic glaucoma, before the sight is much reduced. In those cases Richardson Cross employs the following procedure. The pupil, having been contracted with eserine, a broad keratome is passed—as though an iridectomy were about to be made—from a puncture about 2 mm. outside the corneal margin into the anterior chamber. A wide wound is made, and the knife is carefully withdrawn to avoid prolapse of iris. Cross recommends this sclerotomy, too, when high tension recurs after being temporarily relieved by an iridectomy. The operation may be repeated again and again without danger, should the case demand it.

**Sympathectomy.*—Excision of the superior cervical ganglion of the sympathetic nerve is a new method for the treatment of glaucoma, which is merely mentioned here; for, although of interest, it does not seem likely to come into general use. It is said to act by contraction of the pupil, and reduction of the intraocular blood pressure.

The Treatment of Glaucoma by Myotics.—Eserine and pilocarpine as eye-drops in 1 per cent. solutions often have the power of reducing glaucomatous tension. This power depends on the contraction of the pupil, and consequent drawing away of the base of the iris from the angle of the anterior chamber; and, if the myotic does not contract the pupil greatly, it will not reduce the tension. Cases of acute glaucoma, brought on by the injudicious use of atropine, may frequently be completely and permanently relieved by a myotic instilled a few times. In acute glaucoma of the ordinary type, the use of a myotic in the premonitory stage will often postpone the true glaucomatous attack, and even sometimes relieve the latter for the time; but the myotic treatment cannot produce a radical cure, and it should only be used to preserve the health of the eye, until the operation is performed. In chronic simple glaucoma, also, myotics bring down the tension if they contract the pupil, and may be used in those cases where the patient positively declines an operation, or where an operation in the fellow eye has not resulted satisfactorily, or where an operation is contra-indicated by a very contracted field. The anti-glaucomatous action of the myotic only lasts so long as the pupil is contracted, and it must consequently be applied once or twice in twenty-four hours.

In the myotic treatment of glaucoma, Priestley Smith recommends the combination of cocaine with the myotic in such proportions (say, about $\frac{1}{4}$ per cent. of cocaine to 1 per cent. of the myotic) that the myotic will have the mastery over the pupil. For although, like every dilator of the pupil when used alone, cocaine may promote high tension, yet it has the powers, invaluable in glaucoma, of contracting the ciliary blood-vessels, and of diminishing the sensibility of the ciliary nerves; and, when used in the foregoing manner, the advantage of each drug may be obtained, without any of the disadvantages of either.

It may be here once more stated that, while myotics possess the power of reducing glaucomatous tension, atropine, and all mydriatics, bring on glaucoma, where there is already a tendency to it. In all old people, therefore, before atropine is used, it is well to ascertain that the tension is not too high.

Treatment of Painful Blind Glaucomatous Eyes.—Eyes blind of acute glaucoma may, as has been stated, continue to be painful; and to render the patient's life very miserable. Iridectomy is very commonly performed to relieve the pain, although all hope of restoration of sight is lost; but the operation sometimes fails in its object, and excision, or evisceration, must be resorted to. Mules's operation should not be performed here.

SECONDARY GLAUCOMA.

In addition to the different forms of primary glaucoma above described, we find, as already stated, that high tension occurs as a sequel of diseased conditions previously existing in the eye. There are several diseased states which are liable to become complicated with glaucomatous tension; but it should be clearly understood that, in almost every instance, the immediate cause of the high tension is the same as in primary glaucoma—namely, a closure of the angle of the anterior chamber.

The following are the chief conditions which are liable to lead to secondary glaucoma:—

a. Complete Posterior, or Ring Synechia (*vide* p. 350). The iris, being pushed forwards by the aqueous humour pent up in the posterior part of the aqueous chamber, is pressed tightly against the cornea, and obliterates the angle of the anterior chamber and the ways of exit. An iridectomy relieves the high tension here.

b. Perforating Wounds or Ulcers of the Cornea, followed by incarceration of the iris in the resulting cicatrix. The iris, being drawn tautly towards the cornea, a large portion, or the whole, of the filtration angle may be closed by it. An iridectomy is indicated.

c. Dislocation of the Crystalline Lens into the Anterior Chamber. Here the normal flow of the intraocular fluids through the pupil, towards the filtration angle, is arrested by reason of the presence of the lens in the anterior chamber. The onward current then presses the iris against the posterior surface of the lens, and the root of the iris, which is unsupported by the lens, against the periphery of the cornea, and in this way the angle of the anterior chamber is closed. In these cases the lens must be removed from the eye.

d. Lateral (traumatic) Displacement of the Crystalline Lens. The lens, being pushed in between the ciliary processes and the vitreous humour, drives the root of the iris forwards against the cornea at that place, while in other parts of the circumference the displaced vitreous acts in the same way. In these cases, too, the lens must be removed.

e. Injury of the Crystalline Lens (*vide* chap. xiv.). The swelling lens pushes the iris forwards against the angle of the anterior chamber. Evacuation of the lens should be performed.

f. After Cataract Extraction. For explanation of this see chap. xiv.

g. Intraocular Tumours (*vide* p. 403). The growth of the tumour gives rise to a transudation of serum from the chorioid which detaches the retina, and after a time pushes the lens, the ciliary processes, and the iris forwards, and thus closes the filtration angle.

h. Serous-Cyclitis, or Iritis. Here the filtration angle is not closed. Priestley Smith thinks that the increased tension is due to diminished filtration-power of the eye, and perhaps by tissue changes around the filtration angle, and by deposit of exudation in the angle of the anterior chamber.

Another, and peculiar, form of secondary glaucoma is

***Hæmorrhagic Glaucoma.**—Retinal hæmorrhages of the ordinary type are sometimes followed, a few weeks later, by increased intraocular tension, which generally assumes the symptoms of acute or subacute glaucoma, and, more rarely, those of chronic simple glaucoma. A satisfactory explanation for these cases has not been offered. When such a glaucoma becomes pronounced, it is not usually possible to distinguish it from a primary form of the disease. This disease is practically hopeless. Iridectomy is more likely to do harm than good, the operation being almost invariably followed by fresh intraocular hæmorrhages, and by a further increase of tension. Sclerotomy is said by some to act with fairly good results; but the myotic treatment is powerless.

*CONGENITAL HYDROPHTHALMOS.

Also known as Buphthalmos, and as Cornea Globosa. It is a glaucomatous disease of early childhood, of which the incipient stages are believed to be intra-uterine. The cornea becomes enormously enlarged in diameter, the anterior chamber deep, the iris trembling, and the sclerotic thinned. Increase of tension, often attended by severe pain and cupping of the optic papilla, are usually present.

The Pathology of the disease is obscure. Treacher Collins holds that it is a failure in the separation of the iris from the back of the cornea at its extreme periphery, in course of the development of the eye, whereby the angle of the anterior chamber is blocked; while E. von Hippel believes it to be the result of an intra-uterine inflammation.

Treatment.—Iridectomy and sclerotomy are alike followed by disastrous results in this disease. The myotic treatment is the only one applicable, and in a few cases it arrests the disease.

CHAPTER XIV.

DISEASES OF THE CRYSTALLINE LENS.

Cataract, by which is meant an opacity of the lens, may be said to be the only disease of this part of the eye. Cataract may be complete—occupying, in its final stage, the whole, or nearly the whole, of the lens; or partial—occupying only part of the lens, and with little or no tendency to extend to other parts of it.

Complete Cataracts.

Of these, the most common is **Senile Cataract.** It occurs in persons of over fifty years of age, rarely in those under forty-five years of age.

Progress, Pathogenesis, and Etiology of Senile Cataract.—In incipient senile cataract, the opacity is found in the cortical layers of the lens, especially at its equator, and in the latter position can often only be detected with transmitted light from the ophthalmoscope mirror, or with focal illumination, even when the pupil is dilated with atropine. This opacity takes the form of lines, or of triangular sectors, of which the bases are towards the equator of the lens, while the apices are towards its centre. These lines and sectors look black with transmitted light, but grey with focal illumination, and between them clear lens-substance is present. Or, incipient cataract may first appear as a diffuse opacity in the layers surrounding the nucleus of the lens.

Or, the opacity may commence both near the equator and around the nucleus at about the same time. Or, again, the opacity may in the beginning be disseminated through the cortex, in the form of flocculi, dots, and linos. In some cataracts, in a very incipient stage, there are no absolute opacities; but with weak transmitted light—*i.e.*, from a plane mirror—numbers of fine dark lines will be seen in the lens, which vanish and reappear according as the incidence of the light is altered; while a little later true opacities make their appearance. Gradually the cataract extends to other parts of the lens, until the whole cortical portion is opaque.

In senile cataract, the very nucleus itself does not become cataractous, although it is usually sclerosed (harder and drier). Sclerosis of the nucleus of tho lens is a physiological condition of advanced life, and will be found in many an eye where there is no cataract. It gives to the senile non-cataractous lens, as seen with a dilated pupil or with focal illumination, a peculiar smoky appearance, which is often mistaken by inexperienced persons for cataract; but examination with transmitted light will show that there is no true opacity. When a senile cataract has become complete, the sclerosed nucleus imparts to its centre a brownish or yellowish hue, while the other parts of the lens are of a greyish white. As a rule, the most peripheral layers of the cortex are the last to become opaque. Accordingly as the lens becomes opaque, it often swells somewhat; and in those cases the anterior chamber becomes a little shallower.

Until the whole cortex is opaque, a clear interval will be present between the iris and the cataractous part; and, on examination with the oblique light, a shadow of the iris will be thrown on the cataractous part at the side from which the light comes; and the cataract, in this way, is proved to be immature in the strict sense. If the whole cortical substance be opaque, the thickness of the capsule alone will intervene between the pupillary margin and the opacity, and no shadow of the iris can be thrown on the latter. In addition to this examination with focal light, the pupil should be dilated, and the lens examined by transmitted light from the ophthalmoscope mirror, when a completely opaque cataract should permit of no red reflection being obtained, in any direction, from the fundus oculi.

As soon as the whole of the cortical substance has become opaque, any swelling of the lens subsides, and the anterior chamber finally regains its normal depth. If there be no glittering sectors in the cortex, the cataract is now "mature," or "ripe" for operation—*i.e.*, if an extraction operation be now undertaken, it is possible to deliver the lens in its entirety; whereas, prior to this stage, some cortical substance would have been liable to adhere to the capsule, and be left behind.

But a cataract is immature, despite the absence of shadow from the iris, and of the illuminable pupil, and even though the anterior chamber be of normal depth, if the cortex present well-marked, glittering sectors. The glitter of the different sectors varies with the angle of illumination, so that the surface appears faceted. In such a lens there are thin transparent flakes, as well as opaque flakes, close beneath the capsule; and, if extraction be undertaken, the former are very apt to remain within the eye in spite of every effort to remove them. A few months later the sectors lose their sharp contour, break down, and finally disappear. We can then depend upon the exit of the whole cataract.

Yet in persons over sixty years of age, in whom the nucleus is usually large, many a cataract can be completely removed which does not come up to the strict standard of maturity just laid down; and, at that time of life, the surgeon need not hesitate to operate, without waiting for absolute maturity, if the patient be materially incommoded for want of sight.

The foregoing is the most common course of events in the progress of a senile cataract; but there is a rather rare form of it, in which total opacity of the cortical layers never does come about. In this form the lens is occupied by radiating linear opacities up to the very capsule; but between these opaque lines there are clear intervals, which may even admit of the fundus oculi being examined, although dimly, and which allow of a certain amount of sight. These cataracts can be successfully removed.

After the stage of maturity a cataract gradually goes on to be hypermature. Here one of two changes takes place: either the cortical substance breaks down, and becomes fluid, the nucleus retaining its consistency, and gravitating to the lowest part of the capsule (Morgagnian cataract); or, more commonly, the cortical substance dries up, as it were, and finally comes to form, with the nucleus, a hard flat disc. Accompanying these changes in the lens substance are changes in the epithelium lining the inner surface of the anterior capsule, which result in a thickening of the capsule. In a Morgagnian cataract the fluid cortex finally undergoes absorption, and the anterior and posterior capsules come in contact (cataracta membranacea). In some cases the capsule remains more or less transparent, and the sight may greatly improve. Some cases are on record of spontaneous cure of cataract, due to intracapsular absorption.

The investigations of Priestley Smith have shown that a diminished rate of growth of the lens precedes the formation of cataract; and it is held that the cataractous process in the senile lens is the result, in the first instance, of a rapid sclerosis and shrinking of the nucleus. If the process of sclerosis and shrinking be very gradual, cataract does not appear, because the cortical layers of the lens have time to accommodate themselves to the altered state of things; but, if the shrinkage be rapid, the cortical layers cannot so rapidly accommodate themselves, and then the fibrillæ of these layers become separated somewhat from each other, and fluid collects in the interspaces. This fluid it is which causes the disintegration of the lens substance, gradually leading to opacity of the whole lens. As the opacity increases, more fluid is present in the lens, and it is this which causes the swelling of the lens already referred to. When the whole cortex has become opaque, the fluid contents begin to diminish, and the lens returns to its normal size. Senile cataract, then, is entirely a local process, and is not dependent on any disordered state of the general health.

The dimensions of the nucleus vary a good deal. In some cataracts it is very small, and these are called soft cataracts, as they consist chiefly of the soft cortical substance. In others—and as a rule in patients over sixty years of age—the nucleus is large, and these are called hard cataracts, although they are not hard throughout. The size of the nucleus can be estimated pretty accurately by the extent and intensity of the yellowish or brownish reflection, which is obtainable by focal illumination from the centre of the cataract.

In some senile cataracts, the sclerosis is not confined to the nucleus, but extends to the cortical layers as well. This causes much disturbance of sight, and the term cataracta nigra is given to these lenses, from their very dark hue, although they are not cataracts in the true sense of the term. They require operation, and, as they are always of large size, wide openings have to be made to deliver them.

In the lenses of young people there is no nucleus: consequently, in the complete cataracts of children and of young adults, there is no nucleus; the whole lens becomes opaque, and the cataract is always soft. Although the starting-point of cataract in children and young adults cannot be a shrinking of the nucleus, as there is none, yet the opacity is no doubt due to the taking up of fluid by the lens.

The natives of India are very prone to cataract, and at an early time of life, as are also persons whose business exposes their eyes for hours at a time to the heat and glare of furnaces—*e.g.*, glass-blowers, smiths, cooks, etc.

The Symptoms to which senile cataract gives rise consist, in the earliest stages, in the appearance of motes before the eyes and of monocular polyopia. Motes are complained of also in disease of the vitreous humour; but in those cases they float over a large portion of the field of vision, while in commencing cataract they occupy always the same relative position in the field. The polyopia is the result of irregular refraction in the lens, which causes many images of the objects looked at to be formed on the retina. This symptom seems to annoy the patients more especially in the evening, when they look at gas or candle flames, the moon, etc. It is often complained of before there is any actual opacity in the lens, at a time when only the clefts filled with fluid between the fibrillæ can first be detected with weak transmitted light from the ophthalmoscope, as dark lines vanishing and reappearing according as the incidence of the light is altered.

In some cases of incipient cataract there is an increase in the refracting power of the lens, with the result that the patient becomes slightly myopic, if, previously, he have been emmetropic.

Gradually, as the opacity of the lens extends to other parts of it, the acuteness of vision becomes affected; and this is the more marked the more the cortex at the anterior and posterior poles of the lens is involved. In those cases where the equatorial parts of the lens are but little affected, while the polar regions are a good deal affected, the patients see better in the dusk, or with their backs to the light, than when their eyes are exposed to a strong light. The reason for this is that in the dusk the pupil is dilated, and light can pass through the clearer periphery of the lens, while in a strong light the pupil is contracted. On the other hand, when the opacity is confined rather to the equator of the lens, a strong light is not disturbing to sight; or, if the centre of the lens be quite clear, a strong light may even be agreeable to the patient.

According as the lens becomes more and more opaque, the acuteness of vision is proportionately reduced, until, finally, even large objects cannot be discerned, and only quantitative perception of light is left. Some cataracts, however, when quite ripe, still admit of finger-counting at a few feet.

In advanced stages of the disease, as the opacities occupy a great portion of, or the entire cortex, they are easily recognised even by ordinary daylight, often giving a greyish appearance to the pupil. Inflammatory exudation of some standing in the area of the pupil would afford a somewhat similar appearance, but would be attended by other signs of the previous inflammatory process, such as synechiæ, disorganisation of the iris, etc., and it would be seen to lie more in the plane of the iris than does any lental opacity.

The length of time occupied by the ripening of a cataract varies in different cases from a few months to many years. In the very old the progress is, in general, more rapid than at an earlier time of life. That form which commences at the equator as fine lines is slower than that with flocculent opacities, or than that in which the cortex around the nucleus is likewise implicated at an early period.

All examinations as to the condition of the lens are rendered easier and more conclusive if the pupil be previously dilated with atropine; but the tension of the eye should be ascertained before atropine is instilled, lest glaucoma, or a tendency to it, be present.

Treatment.—No external local applications, nor internal medicines, are of any avail in the treatment of cataract at any stage. Removal of the cataract from the eye by operation is the only cure for blindness caused by it.

In cases of incipient cataract, or in those, rather, which have advanced somewhat beyond this stage, we often find that vision is improved, or made more pleasant, by the wearing of tinted glasses to moderate the light. With commencing cataract, where slight myopia has come on, low concave glasses for distant vision will be found of service; while, for reading, stenopæic glasses sometimes give good results. Yet, as a rule, patients are unwilling to use any of these aids.

Dilatation of the pupil with atropine is in many cases of the greatest benefit, especially where the nucleus is much more opaque than the cortical portion; but sometimes the diffusion of light resulting is most distressing to the patient, and greater impairment and confusion of vision are produced, and for this reason care in the prescription of atropine is demanded.

Patients with incipient or advancing cataract may, with immunity, be allowed to make every use they can of the sight they possess; and the surgeon should give them hints as to the arrangement of light in their rooms, and for their work, etc., so as to enable them to employ their sight to the best advantage.

The truly distressing period in the progress of cataract, when both eyes are affected, lies between the advent of that degree of blindness which incapacitates the patient for reading or writing, or for making his way about alone, and the occurrence of maturity, or of that degree of maturity which is deemed requisite for successful removal. This is often a lengthened time; it may be months or years. Fortunately, in many instances the cataract in one eye is much more advanced than that in the other; and then no such trial need be gone through.

* *Artificial Ripening.*—For the purpose of hastening the maturity of a cataract, when the patient has become incapacitated as above, the following method is sometimes used. The anterior chamber is paracentesed, and, when the aqueous humour has run away, the lens is massaged

with gentle circular motions, with the angle of a strabismus hook, or other suitable instrument, applied to the anterior surface of the cornea. The circular massage must be applied, through the cornea, to the entire surface of the lens as far as its very periphery. Within forty-eight hours the cortex becomes opaque. The proceeding acts by deranging the epithelium of the anterior capsule, after which the aqueous humour can pass through the intact capsule, and produce disorganisation of the lens fibres, as occurs after the operation of discission. Care must be taken that the pressure be not violent, or the capsule may be ruptured, or severe iritis may be caused. This measure is employed less frequently, since it has become the practice to extract cataract in many cases before maturity is reached.

The question, whether the cataract in one eye should be extracted until both eyes are blind, is often asked by patients. The answer is:—A patient with one mature cataract, and the other progressing towards maturity, should have the ripe cataract removed. Hypermaturity is thus avoided, and also the stage of blindness above referred to. Again, if there be a ripe cataract in one eye, and not even incipient cataract in the other, it is often advisable to operate for the purpose of increasing the binocular field of vision.

Complete Cataract of Young People.—The spontaneous occurrence of total cataract in the youthful lens is of rare occurrence, and its pathogenesis is still unknown.

Treatment.—Discission.

Diabetic Cataract.—This is a complete opacity of the crystalline lens occurring in diabetes, and due to disturbed nutrition. It has been proved by experiment that cataract can be produced by injecting solutions of sugar into the blood; but analysis of the aqueous humour in diabetic patients shows, that the amount of sugar contained in it is not sufficient to account for the cataract. The cataract does not differ in appearance or consistency from other cataracts, according to the time of life of the patient.

Treatment and Prognosis.—Contrary to a very general opinion, these cases are not very unfavourable for extraction operations. We have operated on cases of this kind, and always with success, save once, when the eye was lost by intraocular hæmorrhage; and we have seen such cases operated on successfully by others. There is no other method of restoring sight to these patients, who often live many years. But occasionally patients operated on for diabetic cataract die of coma within a fortnight or so after the operation.

The operation of discission in these cases is apt to be followed by severe iritis.

Complete Congenital Cataract.—Children are sometimes born with crystalline lenses opaque in all their layers, while the other tissues of the eye are healthy. With congenital cataract defects of the chorioid or retina, or congenital amblyopia without ophthalmoscopic appearances, are also sometimes present, and these are usually indicated by nystagmus.

Treatment.—Discission.

* **Black Cataract.**—This name, as above stated, is sometimes given to cases of extreme sclerosis of the lens, in which it assumes a dark brown colour; but in other cases the lens is really black, the pigment being derived from the blood (hæmin, or hæmatin). The prognosis for an operation in these latter cases is not good, as they are often complicated with disease of the chorioid, or with hæmorrhages in the vitreous humour.

PARTIAL CATARACTS.

These are nearly all congenital.

* **Central Cataract.**—This is a congenital and usually non-progressive form. It is an opacity of the central, or oldest, lens-fibres, while the peripheral layers remain clear.

Treatment.—Discission or iridectomy.

Zonular, or **Lamellar, Cataract.**—This is congenital, or forms in early infancy, and is the most common kind of cataract in children. It usually is present in both eyes, but it has been seen in one eye only. In it the very centre of the lens is clear (Fig. 168, diagrammatic), while around this is a cataractous layer or zone, and outside that again the peripheral layers are transparent. Most of these cases are non-progressive, but occasionally the whole lens does become opaque, and usually then there have been previously some slight opacities in the otherwise clear cortical layers.

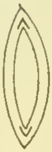

FIG. 168.

With oblique illumination, the cortical layers of the lens are seen to be clear, while towards the centre of the lens a uniform grey circular opacity will be observed. The diameter of this opacity may be small, perhaps not more than 3 mm. or 4 mm., or it may extend very nearly to the equator of the lens. If the pupil be dilated, and the lens examined with transmitted light, the cataractous portion will be seen as a more or less dark disc in the centre of the lens, while all around it is seen the red light reflected from the fundus oculi. The centre of this disc is either of the same degree of darkness as its margin, or but very little darker; and this point serves to distinguish this form of cataract from one in which the whole centre of the lens is opaque. In the latter case it is evident that the centre of the opacity must be darker than its margin. In many cases small radial opacities are seen round the equator of the lens, passing from the anterior to the posterior surface, their concavity embracing the circumference of the central opacity. They are called riders (Fig. 168).

It is probable that lamellar cataract is due to some transient disturbance of nutrition in utero, occurring at the time the affected layers of the lens are being laid down. But against this view is the fact that one half of the lens only may present the appearance of zonular cataract. The subjects of it are usually rickety, as shown by the irregular and imperfect development of the teeth (Fig. 169), and by rachitic alterations in the bones of the skull. Convulsions during infancy in these patients are common.

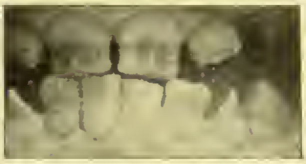

FIG. 169. Rachitic Teeth.

The Treatment of central lental cataract, and of zonular cataract, is similar, and consists in either discission or iridectomy. The latter is very decidedly to be preferred in those cases in which the central opacity is so small that, on dilatation of the pupil, the acuteness of vision, with the aid of a stenopæic slit, is increased in a satisfactory degree. When the improvement is but slight, the breaking up of the lens with a needle is indicated. The advantage of iridectomy over discission, when the former can be adopted, is that no spectacles are afterwards required, and that the power of accommodation is retained.

Congenital cataracts may be needled any time after dentition is completed.

Anterior Polar, or **Pyramidal, Cataract** may be either congenital or acquired. In the former case it must be referred to some inflammatory disturbance occurring about the third period of development of the lens. In both cases the mode of origin of the opacity is the same, whether it be punctiform, flakelike, or pyramidal—namely, by contact of the lens with an inflamed cornea. In fœtal life this may occur without any perforation of the cornea, as there is then no anterior chamber. Fig. 170 shows a case, in which in the left eye a filament

FIG. 170

connects the disc-like anterior polar cataract with an opacity of the cornea. In the right eye there is a pyramidal cataract. After birth a perforating ulcer of the cornea is a necessary precursor of it, but the ulcer need not be central (p. 152). This contact with an inflamed and ulcerating cornea may lead to subcapsular cell-proliferation, at that portion of the capsule which is exposed in the pupillary area, and to consequent subcapsular opacity in this small area.

No *Treatment* is required, as vision is not affected.

* **Fusiform,** or **Spindle-Shaped, Cataract** is also congenital, and is rare. It consists in an axial opacity extending from pole to pole, and may be combined with central or lamellar opacity.

The foregoing forms of cataract, with the exception, perhaps, of the anterior polar and genuine black cataract, are primary; that is to say, they are not dependent on, or the result of, disease in other parts of tho eye.

SECONDARY CATARACT.

Some diseased states of the eye give rise to secondary cataract.

Of this a partial kind is

* **Posterior Polar Cataract.**—This form is seen, with transmitted light, as a star-shaped or rose-shaped opacity in the most posterior layers of the posterior cortical substance, its centre corresponding with the posterior pole of the eye.

Posterior polar cataract is usually found in eyes which are the subjects of disseminated chorioiditis, retinitis pigmentosa, or diseased vitreous humour. It sometimes progresses, and becomes a complete cataract; and then the prognosis for sight after extraction is not very good, owing to the disease which is present in the deep parts of the eye.

The additional disturbance of sight caused by the presence of posterior polar cataract depends a good deal upon its density.

Total Secondary Cataract often ensues upon contact of the lens with inflammatory products in the eye—*e.g.*, where false membranes have been produced by inflammation in the uveal tract. It is called *Cataracta Accreta*, when the iris or ciliary processes are adherent to it. Cataract is also caused by detachment of the retina, intraocular tumour, absolute glaucoma, dislocation of the lens, etc. The reason of this is that the lens, in these cases, imbibes abnormal nutrient fluid from the diseased tissues with which it is in contact.

Such cataracts often undergo a further degeneration, and become calcareous. Calcareous cataracts are easily recognised by their densely white or yellowish-white appearance; and almost always indicate deep-seated disease in the eye, even when the functions, so far as they can be tested, are fairly good.

These secondary cataracts rarely come within the range of *Treatment*, as the diseases which give rise to them are usually destructive of sight. When, occasionally, they can be dealt with they should be extracted.

The term secondary cataract is also used in cases in which, after a cataract extraction, the capsule of the crystalline lens, which is left behind, presents an obstacle to good sight, although here it is not a very suitable term. This will be referred to again, and is not to be classed with the conditions dealt with in this paragraph.

CAPSULAR CATARACT.

By this term is meant an opacity of the anterior capsule, or of the capsular epithelium. It is usually confined to the centre or anterior pole, and is most frequently seen in over-ripe senile cataracts, and in secondary cataracts.

TRAUMATIC CATARACT.

Every injury which opens the capsule of the lens is liable to cause cataract, by reason of the admission of some of the surrounding fluids to the lenticular substance.

Perforating injuries with sharp instruments, or the entrance of small foreign bodies—in both cases, as a rule, through the cornea—are the most common injuries that produce traumatic cataract. But blows upon the eye, without any perforating wound, also, although rarely, produce cataract. In these latter cases there is a rupture of the capsule, either at the equator of the lens, or on its posterior or anterior surface.

Within a few hours after a perforating injury of the anterior capsule, the lens substance in the immediate neighbourhood of the opening becomes opaque, swells, and protrudes as a grey fluffy-looking mass, through the opening in the capsule into the anterior chamber, where it gradually breaks up, dissolves, and becomes absorbed. It is immediately followed by other portions of the lens which have become cataractous, until, after many weeks, the whole lens will have disappeared, and the pupil again become black ; and the eye may see well, if a suitable convex lens be put before it. Marcus Gunn suggests, that the explanation of the solution of the cataract in the anterior chamber consists in the fact, that globulin is normally soluble in a weak solution of chloride of sodium, such as we have in the fluid of the anterior chamber.

But the course of events just sketched is the most favourable one, and is hardly likely to take place in a case which is wholly untreated. In the first place the swelling of the lens—especially if, in consequence of a wide opening in the capsule, it be rapid—is liable to irritate the iris, and to cause iritis ; or to push the periphery of the iris forwards against the periphery of the cornea, block the angle of the anterior chamber, and cause secondary glaucoma.

Moreover, violent plastic or purulent uveitis may come on, as the consequence of the introduction of infective matter on the perforating object, or foreign body, which causes the cataract. Where this occurs, the case enters the category of diseases of the uveal tract; and the cataract, as such, becomes a minor consideration.

Again, we sometimes meet with traumatic cataracts which do not undergo any absorption process, but simply remain stationary; or, in the course of years, they may undergo secondary changes, similar to those which occur in senile cataract. In these instances, the trauma is usually a blow on the eye, not a perforating injury: and it is believed that the rupture of the capsule closes soon after the blow, and hence no lens matter can escape into the anterior chamber; also, the rupture in many of these cases is probably at the equator of the lens, where the aqueous would not readily get access to the lenticular substance.

Occasionally, cataracts caused by blows on the eye (concussion cataracts) take the form of posterior polar cataracts, very similar to those seen sometimes with chorioiditis and retinitis pigmentosa (p. 461), the rest of the lens remaining transparent. These traumatic posterior polar cataracts sometimes clear up spontaneously.

Where the cataract is produced by a small foreign body, which has passed through the cornea and into the lens, it is a matter of importance, for the prognosis, to decide whether the foreign body be in the lens, or have passed through it into the deeper parts of the eye. In the former case we may hope to extract it with the cataractous lens; while in the latter case we must fear that it will set up dangerous inflammatory reaction. In such cases the lens should be well searched with focal illumination, and the transmitted light may also be of use; but it must be remembered that, in these traumatic cataracts, there are often glittering sectors in their deep parts, which may readily be mistaken for a metallic foreign body. If the foreign body be of steel or iron, the sideroscope may be employed for its detection, or, the Röntgen rays be utilised.

Treatment.—The pupil should be kept dilated with atropine, in order to draw the iris out of the way of the swelling lens matter; and nothing more is necessary if complications do not arise. But should iritis, or high tension, come on—and the surgeon must constantly test the tension—it is important, without further delay, to extract as much as possible of the cataract. This may be done either without an iridectomy, through a linear incision some 10 mm. long in the upper third of the cornea, or with an iridectomy, through an incision in the upper margin of the cornea.

If a foreign body be present in the lens, extraction of the latter with the foreign body should invariably be undertaken.

Where violent purulent or plastic uveitis is set up by the trauma, the treatment resolves itself into that required for these inflammations.

*OPERATIONS FOR CATARACT.

With regard to the *State of Health of the Patient* about to be operated on it is desirable, as in every operation, that it should be good. Yet, we have so often in these cases to deal with very old people, that we cannot in every instance require sound organs and a robust constitution; and, as a matter of experience, we have not found serious disease of the heart, lungs, and liver, even when they all existed in the same individual, any impediment to a successful operation. Diabetes is no absolute contra-indication, although, as already stated, coma does sometimes ensue, and even in the presence of Bright's disease a successful operation may be performed. Very advanced years form no obstacle. We have frequently operated for cataract on persons over eighty years of age, and always with success.

The State of the Eye itself should be carefully investigated prior to proposing, or undertaking, an operation for cataract, and is a much more important matter than the general health. Above all things, it is to be determined whether there be intraocular complications, which would neutralise the result of a successful operation, such as detachment of the retina, disseminated chorioiditis, atrophy of the optic nerve, etc. The examination of the eye before the lens has become opaque, if the surgeon have had that opportunity, will be the most reliable basis upon which to go; and, for this reason, a careful note should be taken of the condition of the fundus in each case of incipient cataract. The examination of the fundus of the other eye, if its lens be clear, may help in determining the point, in so far as those intraocular diseases are concerned which are apt to be binocular. Again, the condition of the anterior capsule of the lens should be observed, for a defined glistening white square patch, about 2 mm. broad, situated in the centre of the capsule, tells the tale of intraocular mischief. It cannot be confounded with the more diffused striated and punctated capsular alterations due to over-ripeness.

Finally, the functions of the eye should be examined. With an uncomplicated cataract of the most opaque kind, good perception of light should be present, so that the light, say, of a candle some two metres distant may be distinguished. In less dense cataracts, fingers may be counted at 1 m. or 1·5 m., even when full maturity has been attained. The field of vision must be examined by means of the 'projection' of light—*i.e.*, a lighted candle held in different parts of the field should be recognised by the patient, who is required to point his finger in the direction of the light, as it is moved rapidly from one part of the field to another. This examination can also be made by means of the light reflected from the ophthalmoscope mirror. If the patient fail to project the light in any direction, a diseased condition in the corresponding part of the retina may be suspected. Yet, in cases of very old uncomplicated cataract, the patients often project the light in some one direction, no matter where it may come from. A certain degree of intelligence on the part of the patient is required for this test.

By the foregoing means, most of the intraocular complications of a serious nature can be detected; but there is at least one against which there is no safeguard, namely, a small circumscribed spot of chorioido-retinal degeneration at the macula lutea (central senile chorioiditis). After removal of a cataract from an eye affected in this way, the patient's vision is so much improved as to enable him to go about alone, but reading will still remain an impossibility for him, and to that extent the result of the operation will be a disappointment to patient and surgeon.

The Cornea should be Examined.—Such corneal opacities as would seriously compromise vision may contra-indicate the operation; but slighter opacities, discernible only with oblique illumination, would merely diminish the future acuteness of vision, and would require a corresponding prognosis to be given before operation.

The Condition of the Appendages of the Eye, too, must be examined. Should there be any conjunctivitis, blepharitis, or dacryocystitis, it ought to be cured or alleviated before the operation is undertaken. Very successful operations, it is true, may be performed in the presence of chronic dacryocystitis, or of granular ophthalmia; but, the risk is great, and it is in all respects wiser to reduce their activity to a minimum. In cases of chronic dacryocystitis, extirpation of the lacrimal sac is imperative, prior to a cataract extraction.

EXTRACTION OF CATARACT.

***Linear Extraction.**—The extraction through a linear incision in the cornea is applicable only to soft, or fluid, cataracts, in persons under the age of twenty-five. The instruments required are :—A spring lid elevator, a fixation forceps, a wide keratome or a Græfe's cataract knife, a cystotome, and a Critchett's vectis.

The speculum having been applied, a fold of conjunctiva close to the margin of the cornea, and at the inner end of the horizontal meridian of the latter, is seized (Fig. 171) with the fixation forceps, and the eye fixed by it throughout the operation. The point of the keratome is now entered into the cornea in its horizontal meridian, about 4 mm. from its outer margin, and is passed into the anterior chamber ; or, the incision may be made in the upper part of the cornea. The blade of the knife is then laid in a plane parallel to that of the iris, and pushed on until the corneal incision has attained a length of 6 or 7 mm. The point of the knife being now laid close to the posterior surface of the cornea—in order that no injury may be done to the iris or lens when the aqueous humour commences to flow off—the instrument is very slowly withdrawn, so that the aqueous humour may come away gradually, without causing prolapse of the iris. In withdrawing the knife

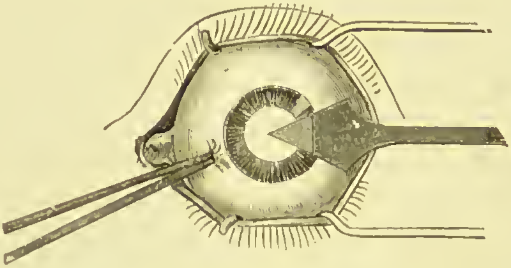

FIG. 171.

it is well to enlarge the inner aspect of one or other end of the wound, by a suitable motion of the instrument in that direction.

The keratome being now laid aside, the cystotome is passed into the anterior chamber (Fig. 172) as far as the opposite pupillary margin, care being taken, by keeping the sharp point of the instrument directed either up or down, not to entangle it in the wound or in the iris. The point is now turned directly on the anterior capsule, and, by withdrawing the cystotome towards the corneal incision, an opening in the capsule of the width of the pupil is produced. The cystotome is then removed from the anterior chamber, with the same precautions as on its entrance.

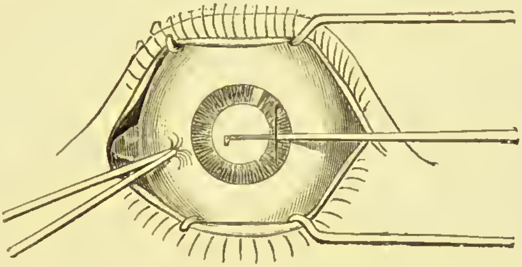

FIG. 172.

The edge of the vectis is then placed on the outer lip of the corneal incision, and the latter is made to gape somewhat, gentle pressure being at the same time applied to the inner aspect of the eye by the fixation forceps, and in this way the lens is evacuated. When the pupil has become quite black the operation is concluded. If pressure do not at first clear the pupil completely, the speculum should be removed, the eyelids closed, a compress applied, and a few minutes allowed to elapse, in order that some aqueous humour may be secreted. A renewal of the efforts to clear the pupil will probably now be successful, or, if not, another pause may be made, and then fresh attempts employed until the pupil is quite clear. It is unwise to insert the vectis into the eye to withdraw the fragments; and, if some of these should be left behind, no ill results need necessarily follow, although iritis is more apt to supervene than if the lens be thoroughly evacuated. Fragments left behind become absorbed. If there be a prolapse of the iris which cannot be reposed, it must be abscised.

***The Three Millimetre Flap Operation,** or, as it is more commonly called, **The Combined Operation** (*i.e.*, combined with an iridectomy). We shall describe the operation as we are in the habit of performing it; and, for success in the cataract operation, it is necessary, not only to select a rational method, but also to devote the utmost attention to a series of minute details in its performance.

Preparation of the Patient.—A gentle purgative is given the day before the operation, so that the bowels need not be disturbed for two days after the operation. The face is washed with hot water and soap, shortly before the operation.

Preparation of the Eye.—Half an hour before the operation, a drop of a sterilised 2 per cent. solution of sulphate of eserine is dropped into the eye. Just before the operation, at intervals of two minutes, three drops of a sterilised 2 per cent. solution of hydrochlorate of cocaine are dropped into the eye. Finally, the lids having been everted, the conjunctival sac is thoroughly washed out with sterilised physiological solution of common salt, particular attention being paid to the fornix of each lid, and to the inner and outer canthus. Then the skin of the eyelids and immediate surroundings of the eye are freely washed with the same solution.

Preparation of the Instruments.—Immediately before the operation, the instruments are sterilised by boiling; and are then plunged for a moment into absolute alcohol, and laid on a sterilised porcelain tray, under a sterilised cloth, until required for use.

During the Progress of the Operation, small bits of sterilised lint, wet with the sterilised salt solution, are employed to wipe away coagula, cortical masses, etc., and are not employed a second time. An assistant should place the instruments in the surgeon's hand in their turn, and take out of his hand those he has used, in such a manner as to render it unnecessary for him to look away, even for a moment, from the field of operation.

The Operation.—A spring wire lid-speculum is applied. The eye is fixed with a catch fixation-forceps by a fold of conjunctiva and subconjunctival tissue, below the vertical meridian of the cornea, or a little to one side of this line (Fig. 173).

The point of the knife is entered just in the margin of the clear cornea, at the outer extremity of a horizontal line which would pass 3 mm. below the summit of the cornea. This line is easily found by placing the knife, which is about 2 mm. broad, horizontally across the cornea, so that a margin of clear corneal tissue 1 mm. broad may remain exposed between the knife and the summit of the cornea. The knife is then passed cautiously through the anterior chamber, and the counterpuncture is made in the corneal margin at the inner extremity of the horizontal line described, and the incision is then finished in the corneal margin by a few slow to-and-fro motions of the knife.

While the incision is being made, the aqueous humour flows away, but, owing to the action of the eserine, the iris does not prolapse. The incision, between puncture and counterpuncture, lies in the clear cornea at its very margin, as represented by the dotted line in Fig. 173.

The Second Stage of the Operation consists in an Iridectomy. The fixation of the eye having been given over to the assistant, the iridectomy is performed by passing a curved iris forceps into the anterior chamber, seizing the smallest possible portion of the sphincter of the iris at a point corresponding to the centre of the incision, drawing it out, and with the forceps-scissors excising a very small central bit of iris. This should be done by approaching the forceps-scissors from over the cornea—*i.e.*, at right angles to the wound—the iridectomy being thus made with one snip of the instrument, and, if care be taken to keep the blades close to the forceps, a narrow, neat coloboma will be obtained. By using a Tyrrell's hook, instead of a forceps, to draw out the iris, a narrow coloboma is obtained, and this stage of the operation is rendered less painful, as the pinching of the iris with the forceps causes pain. A small coloboma, say of 2 mm. to 3 mm. in width, as in Fig. 160, is sufficient to allow of an easy delivery of the lens by doing away with the resistance of the sphincter iridis, and to prevent secondary prolapse of the iris (*vide infra*); and its advantages over a wide iridectomy, from an æsthetic point of view, are obvious. It should be the object of the surgeon to obtain the smallest possible coloboma. The procuring of a neat coloboma is much facilitated if, prior to the operation, the pupil has been contracted (see Fig. 173) by the instillation of one or two drops of solution of sulphate of eserine, as above recommended.

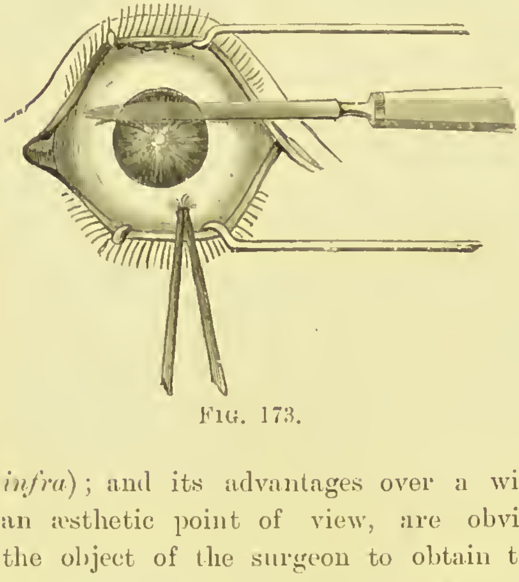

FIG. 173.

The Third Stage of the Operation is the Capsulotomy. The operator takes the fixation forceps from his assistant, who then raises the speculum and eyelids slightly off the globe, in order that no pressure may be exerted on the latter during the remainder of the operation. The surgeon, passing the cystotome into the anterior chamber, divides the anterior capsule of the lens by two incisions, each from the lower pupillary margin upwards, one directed outwards, the other inwards, as far as the anterior surface of the lens can be seen, while finally a third incision is made along the upper periphery of the lens. An extensive opening in the capsule is of great importance, as otherwise difficulty in delivery of the lens may be experienced, and because a small opening renders the occurrence of secondary cataract more likely. In dividing the capsule it is important not to dig into the lens, as this, in the case of a hard cataract, is apt to dislocate it. A rather oblique application of the cystotome to the capsule is, for this reason, the best.

The cystotome as it is withdrawn may pull a tag of the capsule into the corneal wound, where it lies until the end of the operation, and where, owing to its transparency, it may easily pass unnoticed. Such a tag acts as a foreign body, and may subsequently form the starting-point of troublesome complications.

Capsule forceps have been devised for the purpose of taking away a large portion of the anterior capsule; but this does not altogether obviate the danger of capsule in the wound, nor does it do away with the likelihood of secondary cataract. The method has no advantages over that just described, in cases where the capsule is not thickened. But, when the anterior capsule is thickened, it is always desirable to tear away a central portion of it with forceps.

The Fourth Stage is the Delivery of the Cataract. The eye is drawn gently downwards—the patient being called on to assist in this motion by looking towards his feet; the spatula is placed just below the lower edge of the cornea, and gentle pressure is exercised on this place, the pressure being gradually increased, until the upper margin of the lens presents itself in the wound, when, the same pressure being maintained, the spoon is advanced over the cornea towards the wound, pushing the lens before it and out through the wound. When the greatest diameter of the lens has passed the wound, the pressure of the spatula should immediately be diminished, lest rupture of the zonula be caused. The fixation-forceps and speculum are now removed from the eye, and a cold sterilised compress is laid on the closed lids.

It may be noted that the fixation-forceps and the speculum are used until this late stage in the operation. Some operators employ neither fixation-forceps nor speculum from beginning to end of the operation; while others discard the fixation-forceps when the corneal section is completed, but retain the speculum until after the iridectomy only, delivering the lens with the finger placed on the lower lid. The use of the fixation-forceps and speculum until after the lens is delivered gives more security and stability to the operator than the other methods, and it has no counter disadvantages.

The Fifth Stage consists in Freeing the Pupil of any Cortical Masses which may have been rubbed off in the passage of the lens through the wound, and in what is called the Toilette of the Wound.

The presence of cortical remains is recognised by the pupil not having become quite black, or by the vision not being such as it ought to be (fingers counted at several feet), or by inspection of the cataract just removed showing that some portions of it are left behind. The use also of focal electric illumination for the detection of cortical fragments is very advantageous. If any fragments be present, the cold sterilised compress having lain on the eye for a few minutes to enable some aqueous humour to collect, the operator, facing the patient, raises the upper lid with the thumb of the left hand, and then, with the first and second fingers of the right hand laid on the lower lid, he makes light rotatory motions with this lid over the cornea so as to collect the masses towards the pupil, and then with a few rapid light motions upwards, with the margin of the lid, these masses are driven towards, and out of, the wound. Care and delicacy of touch are required in order to perform this lid-manœuvre successfully, without rupturing the hyaloid by undue pressure.

With an iris-forceps the blood-clots which may adhere to the wound are now removed.

To prevent the possibility of any portion of capsule—which may have been drawn into the wound by the cystotome, or pushed into it during delivery of the cataract—becoming incarcerated in the wound during healing, a bent iris-forceps is now passed open between the lips of the wound, closed, and drawn gently out again. Frequently a tag of capsule will have been captured by the forceps, and is snipped off with the scissors, or it may be that no capsule is caught. The forceps is then similarly inserted at an adjacent part of the wound; and in this manner the wound is searched from end to end for capsule.

Finally, the coloboma has to be seen to. The peripheral portions of the iris corresponding to the ends of the wound are apt to have become prolapsed in the course of the operation, and to have displaced the angles of the coloboma upwards. If this be not corrected, the prolapsed portions of the iris heal in the wound, and cause bulgings there later on, the pupil in the course of some months becoming drawn up towards the cicatrix. Hence, in every case, even where everything seems to be in order, it is important to pass the narrow spatula into the anterior chamber, and to gently stroke down each pillar of the coloboma as far as it can be brought. The instillation of eserine, which has been made before the commencement of the operation, will cause the sphincter iridis to assist in producing the desired result. All this is aptly termed the toilette of the wound.

The sight of the eye should then be tested by finger counting, as this affords the patient satisfaction, and lends him courage for the next few days of strict quiet. Finally, the conjunctival sac is flooded with the sterilised saline solution.

The dressing is now applied. A piece of dry sterilised lint, sufficiently large to extend $\frac{1}{4}$ inch beyond the orbital margin in every direction, is laid on the closed eyelids. Pieces of sterilised absorbent cotton-wool are laid on this, the hollows at the inner canthus, etc., being carefully filled up; so that, when the bandage is put on, it may exert equal and gentle pressure on every part of the eye. Three turns of a narrow roller bandage over the dressing and round the head, are applied; but various other, and doubtless equally good, forms of bandage are in use. The pressure of the bandage need only be sufficient to maintain the dressing firmly in its place. The other eye is closed by a light bandage.

We do not recommend the after-treatment of cataract operations without bandage, as advocated by some surgeons.

Accidents liable to occur during the Operation.—The Wound may be made Too Short, and the delivery of the lens, consequently, may be so difficult that the margins of the wound become contused, and consequently suppuration may be promoted. The zonula, too, may be ruptured by the excessive pressure, from efforts to force the lens out through the narrow aperture, and prolapse of the vitreous may ensue. If the directions above given be carefully attended to, the vast majority of both hard and soft cataracts may be extracted without difficulty; but should the wound be made too small, it can best be enlarged by the forceps-scissors, or a blunt-pointed knife made for the purpose. Where the presence of an unusually large hard cataract is diagnosed, it is important to make the incision larger *ab initio*, by placing puncture and counterpuncture nearer to the horizontal meridian of the cornea than above directed.

Hæmorrhage into the Anterior Chamber may take place. It may be from the iris, from the corneo-sclerotic margin, or from the conjunctiva. Pressure with the spatula on the cornea, which causes the wound to gape, is often successful in clearing the chamber of blood, which might interfere with accurate division of the capsule. Yet, when this cannot be completely got rid of, the capsulotomy can be performed by the exercise of greater care. Adrenalin dropped into the eye aids in arresting the bleeding.

Prolapse of the Vitreous Humour. This accident may be caused by undue pressure made on the eyeball by the speculum, fixation forceps, or spatula, or by the lower lid during the lid-manœuvre. It may be due to defective zonula with fluid vitreous humour. When the vitreous prolapses prior to delivery of the lens, the latter falls back into the eye, and can only be delivered by at once drawing it out with a Critchett's, Taylor's, or other suitable vectis; and this must be regarded as one of the most serious accidents which can occur in the course of the operation, for it is often impossible to reach the lens without doing much damage to the eye, as a result of which sight may be lost. Loss of vitreous after delivery of the lens is less serious; indeed, a considerable portion of the vitreous may then be lost without ill result to the eye; yet it increases the traumatism, and renders inflammatory reaction more liable to occur. Opacities in the posterior chamber of the eye are frequently an ultimate result of loss of vitreous; but a much more serious consequence is sometimes seen in detachment of the retina.

Normal After-Progress.—Soon after the completion of a normal operation, the effect of the cocaine having passed off, some smarting commences, and continues for four or five hours. After that time, the patient has no unpleasant sensation in the eye, unless it be some itching, or a slight momentary pain, or sensation of a foreign body, especially when the eye is moved under the bandage. The first dressing is made in forty-eight hours, in a manner similar to that immediately after the operation, a drop of atropine being instilled, as also at each successive dressing; and the sterilised salt solution is used for freely washing the margins of the eyelids, some of it being allowed to trickle into the conjunctival sac. At this first dressing, it is well to abstain from a very minute or lengthened examination of the eye ; but, if the lid be gently raised, the wound will be found closed, the cornea clear, the anterior chamber completely restored, and the pupil semi-dilated and black. The subsequent dressings are made night and morning, for the purpose of instilling atropine. On the third day after the operation the patient may be allowed to sit up, the room being kept moderately dark ; and on the fifth or sixth day the bandage may be left aside permanently, and dark glasses worn in its stead. In the course of a few days more the patient, having been gradually used to more light, may be allowed out of doors. It is desirable to continue the use of atropine for about a fortnight longer, or until all abnormal vascular injection of the white of the eye has disappeared, as until then there is danger of iritis. (For selection of glasses in aphakia see end of this chapter.)

Irregularities in the Process of Healing.—The pain may continue longer than four or five hours, and it is then well to quiet it by a hypodermic injection of morphia in the corresponding temple. Should severe pain come on some hours later, it is apt to be due to an accumulation of tears under the eyelids, and it immediately subsides on the bandage being removed, and exit given to the tears by slightly opening the eye.

Late Appearance of the Anterior Chamber. At the first dressing it will sometimes be found that there is no anterior chamber, although the appearance of the wound is quite satisfactory ; but this need occasion no alarm, as the anterior chamber is sometimes not restored for a week. Should a more lengthened absence of the anterior chamber be noticed, it may be due to the presence of a small tag of capsule, or a small portion of iris, in the wound, and it is then desirable to search the latter with a forceps, and to cut off any capsule or iris which may be found there.

Striped Keratitis. At the first dressing, also, it may sometimes be observed that there is a more or less well-marked striated cloudiness of the cornea, extending over nearly the whole of it, or occupying only a part in the immediate neighbourhood of the wound. This opacity is held by some to be the result of injury to the endothelium of the posterior surface of the cornea during the operation. It is this endothelium which protects the cornea from being infiltrated by the aqueous humour, and the appearance we call striped keratitis is caused by œdema of the cornea. According to another explanation, striped keratitis is due to folding of the posterior layers of the cornea, on account of the difference in tension in the vertical and horizontal directions. Striped keratitis is, for the most part, of no serious import, as it usually passes away in a few days, and leaves the cornea perfectly clear.

Suppuration. With careful aseptic measures this is a rare event. When it occurs, it usually does so between the twelfth and thirty-sixth hour after the operation, rarely earlier or later, and is very serious; for, in the vast majority of cases, do the surgeon what he may, it leads to loss of the eye. Its onset is usually made known by severe pain of a continuous aching kind in and about the eye; and it is thus easily distinguished from the slight, short, stabbing pain, with long intermissions, which some patients complain of, and which has no evil import. On removing the bandage the eye will be found full of tears, and the wound covered with a layer of muco-pus, which can be removed with the forceps in one mass, while the aqueous humour and cornea may already present some opacity. In some hours more, the corneal opacity increases considerably, the iris becomes distinctly inflamed, and the pupil filled with a mass of inflammatory exudation. In many instances the attack commences as septic iritis. The inflammatory process may remain

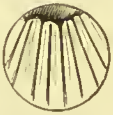

FIG. 174.

confined to the wound and iris, and when, in the course of some weeks, it entirely subsides, it leaves the pupil drawn up towards the wound, so that an appearance as in Fig. 174 is presented. Or, the inflammation may strike into the ciliary body and chorioid, and produce purulent panophthalmitis, with total destruction of the eye. Or, the inflammation may be of the plastic type, leading to destruction of the eye, and threatening the other eye by sympathetic ophthalmitis.

* *To combat Suppuration* the best method is the immediate cauterisation of the corneal wound, if it be the seat of the process, in its whole extent with the galvano-cautery. Also, the wound may be opened up from end to end with a spatula, the aqueous humour evacuated, and the anterior chamber washed out with injections of sublimate solution 1 in 10,000, while the conjunctival sac is irrigated with the same solution. If necessary these measures are to be repeated at intervals of eight or ten hours. Subconjunctival injections of solution of sublimate 1 in 2,000, or of oxycyanide of mercury 1 in 5,000, are often of use in these cases, if they be commenced very soon after the onset of the attack. Half a c.cm. is to be injected as far back as possible under the conjunctiva once, or even twice, in twenty-four hours. From four to eight injections are usually needed according to the severity of the case. Intense chemosis is caused. To relieve the pain of the injection, five drops of a 1 per cent. solution of acoine may be added to the quantity of oxycyanide of mercury solution injected, or to the sublimate injection a few drops of 2 per cent. cocaine solution. But very severe radiating pain usually comes on a quarter of an hour later, and continues for several hours. Hot fomentations afford some relief from this pain. The patient should be confined to bed, and the eye bandaged.

Iritis. A few days after the operation iritis, sometimes of a severe type, may come on. It, too, must be reckoned as due to infection during the operation, especially if some lens-substance have remained, for the latter is a favourable nidus for the cultivation of infective material. The inflammation is ushered in with the usual symptoms of pain, and is generally of the plastic variety. General plastic uveitis may ensue, and sympathetic uveitis may result. *Treatment* consists in strict confinement to a dark room, with atropine, and sub-conjunctival mercurial injections, and quinine or salicylate of soda internally.

Detachment of the Chorioid. Fuchs has pointed out, that detachment of the chorioid occurs some days after cataract extraction, in some of those cases in which the anterior chamber does not form; or in which, having formed, it becomes empty again. The detachment occurs, too, occasionally after iridectomy unconnected with cataract extraction. It can be seen with the ophthalmoscope, and sometimes even with focal illumination. Vision while the lesion is at its height is seriously affected, but the prognosis is good, for the detached portion always becomes reposed.

Cystoid Cicatrix. After convalescence, the cicatrix in the corneal margin sometimes becomes prominent and semi-transparent, presenting the appearance of a vesicle, and may attain a large size. The extremities of the incision are the most common positions for this condition, but it may occupy the entire length of the cicatrix. It does not generally appear for some weeks, or more, after the operation. In some cases it is caused by a tag of iris which is incarcerated in the wound; but in other cases by a small piece of capsule, which has similarly healed in the wound. Irregularity in curvature of the cornea, and consequent irregular astigmatism, are the least of its evil consequences. If the condition be caused by incarceration of iris, the pupil will be gradually drawn close to the upper corneo-sclerotic margin; while, if it be caused by a portion of capsule, irido-cyclitis may be produced. Whether the iris or the capsule be the cause, these eyes are always exposed to the danger of a sudden onset of purulent irido-chorioiditis (see p. 370). All this demonstrates the immense importance of attention to those details of the operation, which are calculated to obviate incarceration of iris, or of capsule, in the cicatrix.

* **Cataract Extraction without Iridectomy,** or, as it is more commonly termed, **The Simple Operation.**—This method differs from the Combined Operation, in that the incision occupies a greater extent (about one-third) of the circumference of the cornea, and lies in the corneo-scleral margin just outside the clear cornea, and that no iridectomy is made. The round pupil, and consequent prettier appearance of the eye, and the diminished tendency to loss of vitreous, and to incarceration of the capsule, are the advantages this procedure has over the Combined Operation as above described; for, vision with a circular pupil is not better, than where a narrow iridectomy has been made.

On the other hand, the extraction without iridectomy exposes the eye to the serious danger of prolapse of the iris into the wound some hours, or days, after the operation. An iridectomy must be made in all cases in which the iris cannot be satisfactorily reposed after delivery of the lens. These are, however, few in number. But, even when the iris can be well reposed, security against the occurrence of a prolapse within the first two or three days after the operation is not obtained; nor does eserine, nor any other means, provide the desired safeguard. Prolapse of the iris does take place after a number of these operations, and there is no means of foretelling in what eyes it will occur. The prolapsed portion of iris heals in the wound, which then, in a few weeks, becomes more or less cystoid and bulging, causing displacement of the pupil and irregular curvature of the cornea, with resulting deterioration of vision. Nor is this all; for such eyes are liable—weeks, months, or even years after the operation—to take on severe irido-cyclitis, ending in total loss of sight. Another disadvantage of the operation is, that removal of cortical remains cannot be so effectually performed, as where a coloboma has been made.

The more peripheral position of the incision (corneo-scleral margin) somewhat reduces the tendency to iris-prolapse, and gives rise to less astigmatism than does an incision in the clear cornea.

Why it is that in the simple extraction, prolapse of the iris with subsequent incarceration is more liable to occur, even some days after the operation, than in the combined operation, and why it is so difficult to devise a sure means for preventing the accident, as, also, how even a very narrow coloboma is, almost always, sufficient to protect the eye from this accident, is as follows:—Within a few hours after the operation the wound in the corneal margin commonly closes, the aqueous humour collects, and the anterior chamber is restored. But it takes many hours more for the delicate union of the lips of the wound to become quite consolidated, and during this time it requires but a slight thing—a cough, a sneeze, a motion of the head, the necessary efforts in the use of a urinal or bed-pan, no matter how careful the nursing—to rupture the newly formed union; and, as a matter of fact, this often does take place. The aqueous humour then flows away through the wound with a sudden gush, and, where the simple extraction has been employed, carries with it the iris. It is that portion of the aqueous humour which is situated behind the iris, which is chiefly concerned in the iris-prolapse; the aqueous humour in the anterior part of the anterior chamber probably flows off without influencing the position of the iris.

The formation of even a narrow coloboma prevents prolapse of the iris when the wound bursts, but this is not because the portion of iris which is liable to prolapse has been taken away, for that would be nothing less than the whole of that part of the iris which corresponds to the length of the wound. The coloboma averts secondary iris-prolapse, by providing a way for the aqueous humour contained in the posterior part of the anterior chamber to escape directly through the wound, without carrying with it the iris in its rush; and the narrowest coloboma which can be formed is amply sufficient for the purpose.

As to disfigurement of the eye resulting from the combined operation, there is practically none, when the coloboma is narrow, and is situated in the upper part of the iris. The pupil, too, is movable, almost, if not quite, as much so, as in most cases of simple extraction; for a narrow coloboma does not render the pupil immovable. Where there are no adhesions between the pupillary margin and the capsule, as frequently happens, the reaction to light is active, a drop of atropine will dilate the pupil widely, and a drop of eserine will contract it.

* **Extraction in the Capsule.**—The ideal cataract extraction is that in which the opaque lens in its capsule is removed, thereby obviating all subsequent trouble due to the capsule; namely, incarceration in the wound and secondary cataract. The serious objection to the method, which has prevented it from coming into general use, is the great danger of prolapse of vitreous which must attend it, owing to the liability of the hyaloid membrane to be ruptured during delivery of the cataract. The operation has been performed by ophthalmic surgeons from time to time, but has recently been specially cultivated in India by Major Henry Smith. His incision lies in the cornea about 3 mm. below its upper margin, the puncture and counter-puncture being in the corneo-scleral margin, as peripherally as possible. The speculum is then removed, and the assistant raises the upper

lid with a strabismus hook, and draws the under lid down with his finger. The curve of a strabismus hook is placed on the cornea in its lower third, and a Daviel's spoon just above the upper edge of the wound. With these instruments gentle pressure and counter-pressure is made, until the lens is more than half delivered; it is then tilted with the hook, and the delivery is completed. The operation may be done with or without iridectomy, but must be performed slowly and cautiously, else the lens capsule may be ruptured, and the object of the method frustrated. Major Smith, in a large number of cases, had loss of vitreous in only 6·6 per cent.

* *Mental Derangements after Cataract Extractions.*—After cataract extractions, during the period of confinement to bed, passing mental disturbances are sometimes seen in old people. This usually takes the form of confusion of ideas, hallucinations, and terror. It is hard to assign a cause for it, but probably it is mainly due to the quiet, and to the exclusion of light if a binocular bandage have been applied, following on a period of some anxiety and excitement. A few doses of sulphonal, and permission to sit up—at least in bed—with removal of the bandage from the unoperated eye, will be the best measures to adopt in such a case; and speedy restoration of mental equilibrium may be looked for with confidence. Care should be taken not to mistake the symptoms of atropine poisoning for this form of mental disturbance.

* *Secondary Glaucoma after Cataract Extraction* occurs now and then, by whatever method the extraction may have been performed. This is contrary to what one would have expected, in view of the diminished contents of the globe, by reason of absence of the lens, and especially where an iridectomy has been made. High tension in these instances may come on soon after recovery from the cataract operation, or after a good result has existed for many years. Treacher

Collins' microscopic investigations show that in these cases either the iris, the capsule, or the hyaloid has become entangled in the wound, and incarcerated in the subsequent cicatrix, and it seems that this leads in some cases to closure of the filtration angle in its entire circumference. Collins says: In all eyes in which glaucoma comes on after extraction of cataract, there is adhesion to or entanglement of the lens capsule in the extraction scar. This adhesion or entanglement keeps the root of the iris—or the most anterior of the ciliary processes, if the iris have been removed up to the periphery—in close contact with the back of the cornea in the region of the coloboma, and so keeps the angle of the chamber blocked in that situation. The advanced position which the capsule takes, by reason of its attachment to the cornea, draws forward the iris lying in front of it, and in this way approximates the root of the iris, elsewhere than in the region of the coloboma, to the periphery of the cornea. In some cases, especially in those in which the extraction scar is very corneal, the advance in the position of the capsule is so great, that apposition of the cornea and iris is actually occasioned. In such cases, the increased tension follows as soon as the wound has closed after the operation. The adhesion of the lens capsule to the extraction scar is sometimes composed of inflammatory exudation; this, on organising and contracting, tends gradually to advance more and more the position of the capsule, and consequently that of the iris. Such a gradual advance would explain those cases, in which the increased tension does not make its appearance, until some time after the cataract has been removed.

Other authors have observed that in some, at least, of these cases, the anterior chamber becomes lined with epithelium which has grown in from the operation wound, and has blocked the angle of the anterior chamber.

A wide iridectomy, or a sclerotomy, should be made as soon as possible after the high tension shows itself, and by this means many of these eyes may be saved. Simple division of the capsule has produced a good effect in some cases.

* *Erythropsia after Cataract Operations.* For an account of this see chap. xx.

* *Secondary Cataract.*—The term secondary cataract, as here employed (compare p. 461), usually means a closure of the opening which is present in the anterior capsule after the removal of a cataractous lens, with a thickening of the capsule in some of the cases, whereby an impediment is offered to the rays of light in passing through the pupil. The thickening may have pre-existed in the capsule, or it may be due to subsequent proliferation of the epithelial cells on the inner surface of the capsule. The term is also used with reference to those cases in which no central opening has been made in the capsule (peripheral capsulotomy), and where the latter causes imperfect vision. It is also used in those cases where, after cataract extraction, an exudation in the pupil, consequent upon iritis, has occurred. Finally, and very incorrectly, it is applied to the cases which Fig. 174 represents, in which, after suppuration of the wound with irido-cyclitis, the iris is dragged upwards, and the pupil is consequently obliterated.

The most simple form of secondary cataract occurs as a very fine cobweb-like membrane—the capsule of the lens—extending over the whole area of the pupil, which can often only be discovered by careful examination with oblique illumination. It may not cause any trouble of vision until some months after the extraction, when a little thickening of it may have taken place.

Capsulotomy, as the operation for making a clear opening in the membrane is called, is best performed with a Knapp's needle-knife. This instrument has a blade 4½ mm. in length. It cuts on one side only, and the blade and the evenly rounded shaft are so proportioned, that the shaft fills exactly the opening made by the blade, and consequently the needle can be moved within the anterior chamber in every direction, without escape of aqueous or bruising of the cornea. The instrument must be of the utmost sharpness in point and edge, so that it may cut, and not tear. The point of the needle-knife is entered through a thin part of the capsule, and an opening is cut in it, hard and inelastic bands being avoided.

Iridotomy is the operation used for the cases as in Fig. 174, where the iris forms a complete and tightly stretched curtain across the pupil. A vertical incision having been made in the cornea, about 3 mm. long, and the same distance removed from its inner margin, the closed blades—one of which has a sharp point—of de Wecker's forceps-scissors are passed into the anterior chamber. The blades are then opened, and the sharp point of one of them is forced through the stretched iris, and some 3 or 4 mm. behind it. By closing the blades the tightened iris fibres are cut across, and on their retraction a central clear pupil is formed in the iris and retro-iridic tissue.

* **Discission** means the tearing of the anterior capsule of the lens with a needle, so as to give the aqueous humour access to the lenticular fibres, which causes them to swell, and gradually to become soft, and then to be absorbed. The larger the capsular opening, the more freely is the aqueous brought in contact with the lens, and the more rapid is its swelling. The rapidity of the swelling and absorption depend, also, on the consistence of the lens. The softer it is the more rapid is the process, the completion of which may require from a few weeks to many months. It is wise to make the first discission of moderate dimensions, in order to test the irritability of the eye, especially in adults.

The instruments required are a spring speculum, a fixation-forceps, and a discission needle. The pupil is to be dilated with atropine.

The eye having been cocainised, the speculum applied, and the eye fixed close to the inner margin of the cornea, the needle is passed perpendicularly through the cornea in its lower and outer quadrant, at a point corresponding to the margin of the dilated pupil. It is then advanced upwards to the upper margin of the pupil (Fig. 175), where it is passed into the capsule, but not deeply into the lens, and a vertical incision is effected by withdrawing the instrument slightly. If an extensive opening in the capsule be wished for, a horizontal incision can be added to the vertical one by a corresponding motion of the needle. During these manœuvres the cornea, at the point of puncture, must form the fulcrum for the motions of the instrument. The instrument is then withdrawn from the eye, and some aqueous humour escapes through the opening. Atropine is instilled, and the bandage applied. The patient is kept in bed for a day, and then the bandage may be dispensed with, and dark spectacles worn. The iris is to be kept well under the influence of atropine, until the absorption of the lens is completed. Repetition of the operation is called for, if the opening be so small as to admit of but a very slow absorption of the lens, or if, as sometimes happens, the opening should close.

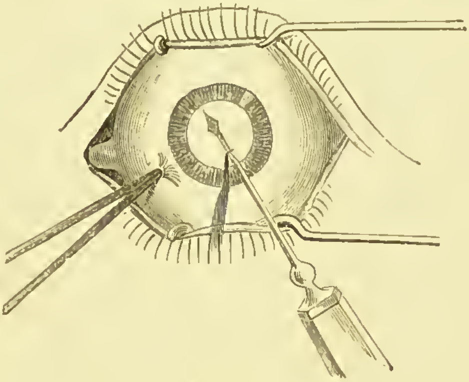

FIG. 175.

This method is applicable to all complete cataracts up to the twenty-fifth year of age, and to those lamellar cataracts up to the same age in which the opacity approaches so close to the periphery of the lens, that nothing can be gained by an iridectomy (p. 459). After the above age, the increasing hardness of the nucleus, and the increasing irritability of the iris, render the method unsuitable.

Discission is a safe procedure, when used with the above indications and precautions. The danger chiefly to be feared is iritis, from pressure on the iris of the swelling lens masses. When this occurs, or is threatened, removal of the cataract by a linear incision in the cornea should be at once performed.

Another danger consists in glaucomatous increase of tension (secondary glaucoma), which may come on without any subjective symptoms—although severe pain usually attends it—while the absorption of the lens still runs its proper course. It may happen, consequently, that, when absorption of the cataract is completed, the eye will be found blind from glaucoma. Frequent testings of the tension of the eye during the cure are therefore a most important precaution. Should the tension rise, removal of the lens through a linear incision in the cornea is at once indicated.

* **Dislocation of the Crystalline Lens.**—This may be congenital (p. 491), or it may be the result of disease, such, for example, as anterior sclero-chorioiditis; or it may be caused by a blow on the eye.

The dislocation due to disease or trauma may be partial or complete. Partial dislocation is often so slight as to be discoverable only when the pupil is widely dilated, the margin of the lens becoming then visible, by aid of the ophthalmoscope mirror, as a curved black line in some one direction; or, the displacement may be so great as to bring the margin of the lens across the centre of the undilated pupil, in which case one part of the eye will be highly hypermetropic, while in another part it will be myopic. Complete dislocation may take place into the anterior chamber, into the vitreous humour, or even under the conjunctiva, if the sclerotic have been ruptured.

The symptoms in partial dislocation are those of loss of power of accommodation, and monocular double vision. Iridodonesis (*i.e.*, trembling of the iris when the eye moves) is present, as a rule, in consequence of the loss of support provided for the iris by the lens. In complete dislocation the symptoms are those of aphakia—*i.e.*, extreme hypermetropia, and want of power of accommodation.

Treatment.—In partial dislocation it is rarely that any treatment can be of service. The prescribing of spectacles suited, so far as it is practicable, to the faulty refraction is indicated. In complete dislocation of the lens into the anterior chamber, its extraction is usually required, especially if it cause symptoms of irritation. Dislocation into the vitreous humour is generally unattended by irritation; but when the latter does arise, removal of the lens by aid of a spoon, through a peripheral corneal incision, has to be attempted.

* **Congenital Defects of the Lens.** *Congenital Cataract.* (See pp. 458, 459, 460.)

Ectopia of the Lens (Congenital Dislocation).—This is often hereditary, and often present in more than one member of a family. The displacement is more frequently in an upward direction than in any other. It is usually in both eyes of the patient. It is due to a mal-development of the zonula of Zinn, which in these cases is shorter in the direction towards which the lens is luxated. Discission or extraction are not indicated here. Occasionally some advantage is gained for vision, by the correction with glasses of one or other portion of the doubly refracting eye.

Coloboma of the Lens.—Coloboma of the lens often coexists with coloboma of their is (p. 409), but may be present alone. It is generally in the lower periphery of the lens.

Lenticonus.—This is a rare congenital anomaly of the lens, in which its anterior surface, or, still more rarely, its posterior surface is cone-shaped. The derangements of vision are very similar to those caused by conical cornea.

Aphakia (*ἀ, priv.*; *φακός, a lentil, lens*), or **Absence of**

the Crystalline Lens.—The condition of the emmetropic eye after the removal of a cataract is one of high hypermetropia, and the power of accommodation is wanting. Consequently, in order that the eye may have the best possible sight for distant objects, a high convex glass has to be experimentally found to suit it, and stronger lenses must be prescribed for shorter distances.

The degree of vision obtained varies considerably in different cases; frequently $V = \frac{6}{6}$ is obtained, but $V = \frac{6}{18}$ may be regarded as a satisfactory result; and even lower degrees, which enable the patients to find their way about with comfort, are classed as successful operations. The vision often improves for some months after the operation, patients who at first had only $\frac{6}{18}$, or so, advancing up to $\frac{6}{9}$ or $\frac{6}{6}$. For reading, writing, etc., at about 25 cm., a still higher convex glass must be provided. If the correcting lens for distant vision be + 10 D, its power, for the purposes of vision at 25 cm., must be increased by the lens which would represent the amplitude of accommodation from infinite distance up to 25 cm. This lens is 4 D (because $\frac{100}{25} = 4$); therefore + 14 D is the lens required. With these two lenses most patients are satisfied. For distinct vision at middle distances, they learn to vary the power of the lenses by moving them a little closer to, or farther from, the eye; but, if necessary, a lens can be prescribed for distinct vision at any desired distance.

In the case of hospital patients, one is often obliged to select the + glasses a fortnight or three weeks after the operation, but the result is more satisfactory when the selection can be postponed for six weeks or two months. Permanent wearing of the + glasses should not be permitted until all redness of the eye has passed off, and this varies in different cases. Until then, also, dark protection spectacles should be worn.

In the majority of cases, after cataract operations, the best vision is not obtained until a certain degree of astigmatism is corrected. This astigmatism is caused by a flattening of the vertical meridian of the cornea, due to the incision at its upper margin, and hence it is against the rule (see p. 72). An obliquity in the incision often produces an obliquity in the principal meridians of the astigmatism. The degree of astigmatism varies, and may be very high. It rapidly reaches its maximum after the operation, and then gradually diminishes for weeks or months, and in some cases completely disappears; hence it is, that glasses for permanent use can be better prescribed a month or two subsequently to the operation.

CHAPTER XV.

*DISEASES OF THE VITREOUS HUMOUR.

Purulent Inflammation of the Vitreous Humour (to which, unfortunately, the name pseudo-glioma is sometimes applied) occurs only as the result of perforating injuries, or of the lodgment of a foreign body, or as an extension of a purulent process from the chorioid (p. 370).

Ophthalmoscopically, a purulent deposit in the vitreous humour gives a yellowish reflection, when light is thrown into the eye with the ophthalmoscope mirror, or on examination with oblique light. It is to be distinguished from a somewhat similar appearance in glioma of the retina, by the history, by its early complication with more or less severe iritis, by the very frequent retraction of the periphery of the iris, with bulging forwards of its pupillary part, and by the diminished tension of the eye, while a lobulated appearance is not so usual in it as in glioma. Again, in glioma the vitreous humour remains clear, while in this disease it is hazy.

The condition, if at first confined to the vitreous humour, soon extends to the surrounding tissues, and usually leads to panophthalmitis and complete destruction of the eye.

*** Inflammatory Affections of the Vitreous Humour, other than the purulent form,** are for the most part the consequence of diseases of the chorioid (including those which accompany high myopia p. 57), ciliary body, or retina, and display themselves as opacities of various kinds. These are either cells derived from the primarily diseased tissue, or they are secondary changes (connective tissue development) in the vitreous humour, the result of the cellular invasion.

The chief *Varieties of Vitreous Humour Opacities* are:—(1) The Dust-like Opacity so characteristic of syphilitic disease of the retina and chorioid. It may occupy the entire vitreous humour, but is frequently confined to the region of the ciliary body, or to that of the posterior layers of the vitreous humour. (2) Flakes and Threads. These occur with chronic affections of the chorioid or ciliary body, and may be the result also of hæmorrhages into the vitreous humour. They invade every portion of the humour. (3) Membranous Opacities, which are rare, and are probably the result either of extensive hæmorrhagic extravasations or of chorioidal exudations.

Most of the alterations in the vitreous humour are attended with, or give rise to, fluidity of it, or Synchysis.[1]

The Diagnosis of opacities in the vitreous humour is made with the ophthalmoscope mirror and a not very bright light, or with the plane mirror. If a very bright light and a concave mirror be employed, the finer opacities will not be readily seen. The pupil being illuminated, the patient is directed to look rapidly in different directions, when the opacities will be seen to float across the area of the pupil, as they are thrown from one side of the eye to the other in the fluid vitreous.

Opacities in the vitreous can be distinguished from those in the lens by the fact that the latter are fixed, and are arranged mostly in a radiating manner.

Another and very fine method for the detection of delicate opacities in the vitreous consists in placing a high + lens, say + 10 D, behind the ophthalmoscope mirror, and then going close to the eye, as in the examination of the upright image. Minute opacities will then be seen as black dots floating in the vitreous humour.

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[1] *σύν, together; χέω, to pour.*

The ophthalmoscope does not always detect changes in the chorioid or retina, when there are opacities in the vitreous; and in many such cases we are led to the belief, either that the diseased changes in the chorioid or retina are too fine to be seen with the ophthalmoscope, or that they are situated in the region of the ciliary body which is out of view.

Vision is affected by opacities in the vitreous humour in proportion to their density, and to the extent to which the vitreous humour is occupied by them. The patients often observe them as floating positive scotomata in their field of vision. These entoptic appearances are caused by the shadows of the opacities thrown on the retina.

The Prognosis depends on the cause of the opacities. The dust-like opacities accompanying specific retinitis are favourable for absorption, while the flake and thread opacities, frequently remain as permanent obstructions. Moreover, by shrinking, many of the more organised opacities give rise to detachment of the retina from the chorioid, and consequent blindness.

Treatment consists, above all, in that for the exciting cause. Besides this, Heurteloup's artificial leech, or dry cupping on the temple, is useful; and in many cases, soon after the application, a marked clearing up of the vitreous is apparent.

Sub-conjunctival injections of a 4 per cent. sterilised solution of chloride of sodium are valuable in clearing up opacities in the vitreous humour, in many chronic or sub-acute cases. They are not used if there be acute uveitis present. Ten to twenty minims are injected, the point of the needle being entered far back near the fornix, towards which the injection is made. The inclusion of 5 minims of a 1 per cent. solution of acoin in the injection lessens the subsequent pain, which is often severe; but, by some, the acoin is held to increase the tendency to inflammatory sequelæ of the injection, such as cicatrices of the conjunctiva, and adhesions of the latter to the sclerotic. Hot fomentations to some extent relieve the severe pain. The injection is repeated after a day or two, when the swelling and irritation have subsided. Usually not more than two or three injections can be given in a week.

Injections of sublimate solution, 1 in 5000 to 1 in 2000, or of oxycyanate of mercury solution, 1 in 5000—of which 5 to 10 minims with one or two minims of 1 per cent. acoin solution are injected—are preferred by some, especially in syphilitic cases. They are more painful than the saline injections, more likely to cause conjunctival lesions, and they do not seem to be more efficacious. Sub-conjunctival injections enter largely, also, into the therapy of chronic uveal diseases (pp. 363, 367, 369, 370, 386), of certain corneal diseases (pp. 216, 218, 227, 235, 245, 246, 248, 249, 252), and of some other diseases of the eye (p. 480). It has been held that the mode of action of saline injections is, that this solution is a lymphagogue, and hastens the lymphatic circulation of the eye. Those who favour mercurial solutions, hold the improbable theory, that these solutions penetrate the sclerotic by the lymphatic vessels, and act locally on the diseased tissues. The most probable and rational theory is, that subconjunctival injections, whatever substance may be used, act merely as local irritants, setting up a certain beneficial reflex hyperæmia, which favours absorption of inflammatory exudation. Hence, they are indicated only where the hyperæmia present is insufficient for this purpose, and a stimulus to the circulation is needed, but not where the hyperæmia is excessive, as in acute uveal inflammations.

* **Hæmorrhage in the Vitreous Humour.**—This is often caused by blows on the eye, which rupture intraocular blood-vessels. It is the result, too, of certain diseases of the retina and choroid, which are accompanied by hæmorrhages in those membranes; or of disease of the coats of the

retinal or chorioidal vessels. It is seen in old people with atheromatous vessels, and it occurs in pernicious anæmia, syphilis, and malaria. Some quite healthy young people of both sexes, are liable to recurrent hæmorrhages in the vitreous humour, which on ceasing either leave the vitreous humour clear, or it may remain more or less opaque. Strands of connective may form in it, and even detachment of the retina may ultimately come on. No explanation for these cases in young people can be offered. The arterial tension is often high, constipation is often present, and there may be epistaxis.

Hæmorrhages in the vitreous humour, when viewed with the ophthalmoscope, present the appearance of very black floating masses, between which the chorioidal reflex appears, and, if they lie in the anterior part of the vitreous chamber, they may be seen with focal illumination, and then are red. When the vitreous humour is full of blood, no red reflex can be obtained with the ophthalmoscope, and the pupil looks quite black.

Treatment. Saline sub-conjunctival injections afford the best hope of promoting absorption of vitreous humour hæmorrhages. In recent cases rest in bed is important.

Mouches Volantes, Muscæ Volitantes, and **Myodesopsia**[1] are terms applied to the motes which people frequently see floating before their eyes, but which do not interfere with the acuteness of vision, nor can the ophthalmoscope detect opacities in the vitreous humour, nor any other intraocular disease. These motes are most apparent when a bright surface, such as a white wall or the field of a microscope, is looked at. Mouches volantes have no clinical importance. Those annoyed with them should be strongly recommended not to look for them, as in that case others are very apt to become visible. They depend, probably, upon minute remains of the embryonic tissue in the vitreous humour.

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[1] μυῖα, *a fly*; ὄψις, *seeing*.

* **Fluidity of the Vitreous Humour,** or **Synchysis,** is not rare. It can only be diagnosed with certainty when the humour contains floating opacities. Low tension of the eyeball does not always indicate fluidity of the vitreous, although soft eyeballs nearly always contain fluid vitreous humour. Trembling of the iris (iridodonesis) is also no sign of fluid vitreous, but merely indicates that the iris is not supported in the normal way by the crystalline lens. Defective zonula of Zinn, however, is often caused by, or is a concomitant of, fluid vitreous, and, by causing displacement of the lens, would allow of trembling of the iris.

The Causes of synchysis are chorioiditis and staphyloma of the chorioid and sclerotic, and it also occurs as a senile change.

Fluidity of the vitreous humour is not, *per se,* a condition of serious import, unless the eye come to be the subject of an operation involving an incision in the corneo-sclerotic coat, when it renders prolapse of the vitreous more liable to take place.

* **Synchysis Scintillans** is a fluid condition of the vitreous humour, with cholesterine and tyrosine crystals held in suspension in it. The ophthalmoscopic appearances are very beautiful, resembling a shower of golden rain. A satisfactory explanation for the occurrence of these crystals in this position has not yet been given. They usually occur in old people, and seldom cause any marked deterioration of vision.

Foreign Bodies in the Vitreous Humour and Interior of the Eye in General.—One of the most common and most serious accidents to the eye is perforation of the sclerotic, or of the cornea and crystalline lens, by a small foreign body (shot, morsel of iron, copper, stone, or glass), which then lodges in some part of the interior of the eye—very frequently in the vitreous humour.

The danger of leaving a foreign body in the eye is great. It is rarely that, whether it remain free, or, as sometimes happens, become encapsuled, it is tolerated permanently in any part of the interior of the eye; and that event should never be reckoned on in the treatment of such a case.

As a rule, foreign bodies in the vitreous, or elsewhere within the eye, soon produce violent inflammatory reaction. This occurs, either by reason of infective micro-organisms being introduced into the eye with the foreign body, or, it may be caused by the oxidisation of the foreign body, when it is of iron or copper. The form of inflammation may be either a plastic or a purulent uveitis, in the latter case with purulent infiltration of the vitreous humour and hypopyon.

An eye which contains a foreign body that is not, or cannot be, at once removed, may be regarded as lost; and such an eye becomes, moreover, one of the surest sources of sympathetic ophthalmitis, when plastic inflammation is set up.

It is, consequently, of the utmost importance to decide whether or not a foreign body be in the eye; and if one be there, to remove it if possible, should a reasonable prospect of saving sight, even partially, exist; and this too, with the least delay.

Means of deciding whether a Foreign Body be in the Eye.—If the case be seen immediately, or soon after the accident, and there be no intraocular hæmorrhage to obscure the view, the foreign body may perhaps be detected with the ophthalmoscope in the vitreous humour or fundus oculi as a dark or glittering body, according to its nature; and focal illumination with dilated pupil will often help us to discover a foreign body situated in the anterior part of the vitreous humour. Or, if it cannot be seen, an opaque streak through the vitreous humour, one end of which corresponds with the sclerotic wound, may indicate the track taken by a foreign body.

In case the foreign body have perforated the cornea, and reached the vitreous humour through the circumlental space, a counter-opening will be found in the iris; while, if it be supposed to have passed through the cornea and lens, the openings both in the anterior and posterior capsule of the lens should be sought for.

In cases where the ophthalmoscope and focal illumination fail us, owing to extravasation of blood, traumatic cataract, etc., it is sometimes not easy to say whether the foreign body be in the eye, or whether it may merely have punctured the sclerotic, or cornea, without passing through the globe, and then fallen to the ground. If it be known to have been a small foreign body, which has flown against the eye with force, the probabilities are that it is lodged in the eye.

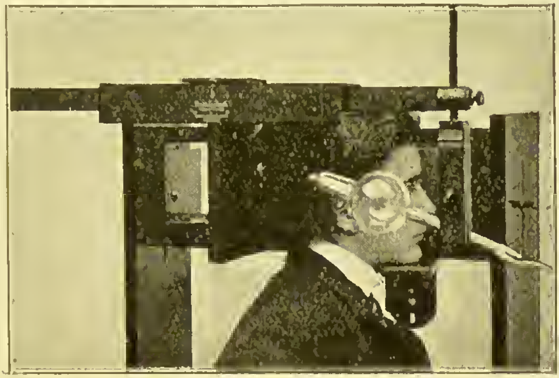

FIG. 176.

The Röntgen Rays must then be resorted to, should the foreign body be of any metal or of glass, to decide both upon its presence and position, and the sideroscope is useful for the same purposes, but only if the object be of iron or steel.

* The following is Mackenzie Davidson's method for employing the X Rays in these cases:—

The patient sits upon a chair in an upright position, with his head fixed in a headpiece (clamped to a table) to keep it steady (Fig. 176), while at the same time a photographic dry plate can be placed against the temple on the side of the eye which is to be photographed.

Fig. 177 is a picture of a patient's head in position for taking the right eye. The back of the head rests against a board, and another board, with a thumb-screw sliding in a groove, serves to press and fix his head laterally against two stretched piano-wires, behind which again the photographic plate is placed. The chin is supported on an adjustable projection.

Fig. 178 is a side view of the same patient. The stretched piano-wires are shown. The patient, while the skiagram is being taken, is made to fix his gaze on a distant object, so that his optic axis is parallel to the horizontal wire. Previously, a small piece of lead wire, exactly 1 cm. long, is placed on the lower eyelid, and secured by two strips of adhesive plaster, and the relative position of the point of the wire (nearest the eye) is carefully noted in relation to the cornea (*e.g.*, so many millimetres vertically below the centre of the cornea, or so many millimetres vertically below any corneal scar which may happen to be present); also whether the point is on a level

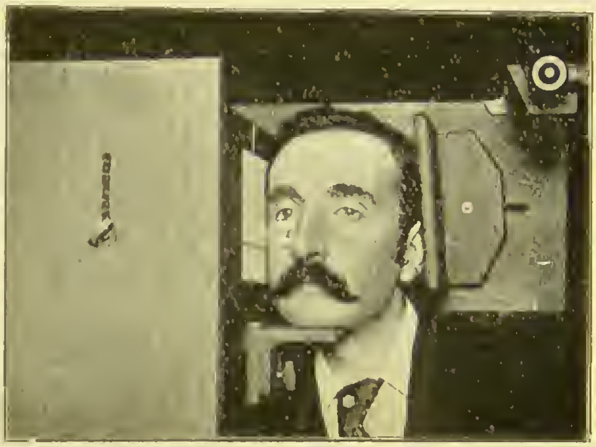

FIG. 177.

with a vertical line from the centre of the cornea (as it usually is), or how far behind or in front of this plane. These are all the adjustments necessary to be made with the patient.

Before the patient is placed in position, the Crooke's tube is adjusted, so that the fine point on the anode, from which the linear X rays originate, shall be exactly opposite the point of intersection of the two stretched piano-wires. When the tube is worked by the coil, this point shows as a bright incandescent spot on the anode, if it be of osmium; and by means of a fixed 'sight,' placed on this side of the wires, the tube can be so adjusted that this point is exactly opposite the intersection of the wires. The distance is carefully noted: it is usually 28 to 30 cm. The tube-holder is fixed to a bar of wood, which slides horizontally, and by means of marks placed on the bar itself, and upon the edge of the groove in which it slides, it can be displaced in a plane exactly parallel to the horizontal wire. It is to be dis-

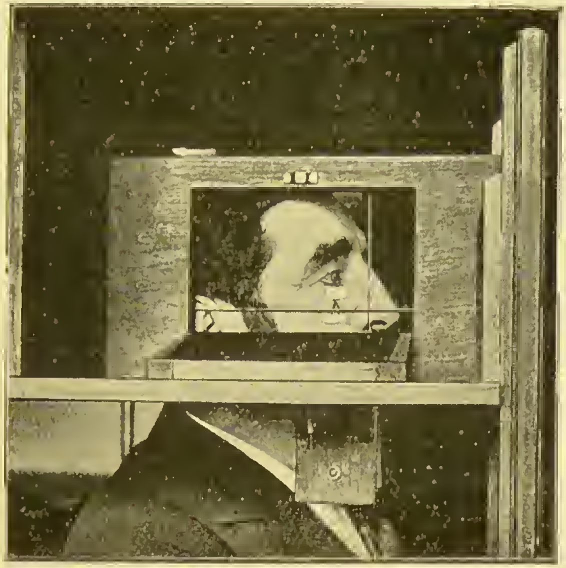

FIG. 178.

placed 3 cm. to one side of the vertical or zero point. Then a photographic plate, protected, as usual, in black paper, is placed against the wires (see Fig. 178), and an exposure given of from ninety seconds to two minutes. With exceptionally good osmium tubes ten seconds is enough. The tube is then displaced 3 cm. to the other side of the zero point—the photographic plate having been removed and a fresh one put in its place—and a second similar exposure is given. The result is two negatives taken from two points of view 6 cm. apart.

A transparent sheet of thin celluloid has two cross lines marked upon it at right angles to each other. One side is varnished, so that it will readily take pencil marks. Immediately after development and fixing, this sheet of celluloid is placed over the film side of the negative, so that its two lines are exactly superimposed upon the white lines left by the wires in the headpiece; while firmly held in position, the shadow of the leaden wire or landmark, placed on the lower eyelid, is carefully traced. Then the foreign body is traced in the same way. This process of tracing is repeated with the other negative. The result is that upon the sheet of celluloid two tracings of the leaden landmark wire, and two tracings of the foreign body, side by side, are obtained.

This celluloid tracing is now placed upon the horizontal glass stage of the Cross-Thread Localiser. The latter has two fine silk threads coming from two points, which are so adjusted as to occupy relatively the two positions occupied by the anode of the Crooke's tube, and to be at the same distance from the celluloid tracing, and also in the same relative position to the cross-lines, that the anode of the Crooke's tube had to the photographic plate and to the cross-wires of the headpiece, when the photographs were being taken.

The silk threads are now used to trace the linear paths of the X rays. The intersection of the two threads fixes the position of the object in space. Its geometrical relations to the known data can then be measured. First, the three co-ordinates of the known point are ascertained, then the three co-ordinates of the unknown foreign body, and then, by simple subtraction, the minor co-ordinates are obtained, and thus the position of the foreign body is accurately determined. The observer is enabled to say how far horizontally inwards or outwards the foreign body lies from the point of the landmark lead wire; from that point how far vertically upwards or downwards it lies; and finally, how far directly backwards, parallel to the visual axis, it is situated. If care be taken, the position of a foreign body, however small, can be ascertained with great accuracy by this method. Its size also can be discovered. Moreover, the two negatives are stereoscopic, so that, when viewed either in a Wheatstone's reflecting stereoscope, or by converging the optic axes, and so fusing the pictures, a single picture in relief is seen, showing the relative position of the parts in a very beautiful manner.

* *The Sideroscope* is used for the detection of the presence of atoms of steel or iron in the eye. It consists in a magnetic needle hung by a fine thread, and so mounted that when it is brought close to the eye containing the foreign body, its deflections can be read by means of an astronomical telescope which is attached. The sideroscope is used, too, for ascertaining the position of the foreign body, which is nearest to the part where the deflection of the needle is greatest. This, of course, is only an approximate localisation.

This method is not much employed in these countries, as the Röntgen Ray method fulfils the requirements more completely. Having decided that a foreign body is in the eye, and having located its position there, its removal must be attempted.

* *Removal of a Foreign Body from within the Eye.*—In all these operations it is necessary that the patient be deeply

under the influence of an anæsthetic, in order that as little vitreous humour as possible may be lost. If the foreign body be not of iron or steel (glass, copper, stone, etc.), it may sometimes be removed through an incision in the sclerotic, which is either an enlargement of the opening made by the foreign body, or is a special one, at a point more nearly corresponding to the actual position of the foreign body in the eye. This incision should lie between two recti muscles, should have an antero-posterior direction, and, in order that it may gape but little, should be a puncture with a broad keratome. Prolapse of the vitreous is then produced by pressure on the eyeball, and the foreign body is evacuated.

This method may be tried only when the foreign body is situated in the periphery of the vitreous, and towards the equator of the eye, where the opening for its exit can be made in its immediate neighbourhood; but the proceeding is often attended with disappointment, much vitreous being lost, while the foreign body remains in the eye.

Or, a forceps is passed in through the opening, and while the foreign body is kept in view with the ophthalmoscope it is seized and drawn out. This plan is also unsatisfactory, as, loss of vitreous occurring, the cornea becomes flaccid, and the view of the foreign body is soon obscured.

Some surgeons prefer to make their opening not close to the foreign body, but exactly at the opposite side of the eyeball, by which means they can often reach the foreign body with greater ease, and with less injury to the tissues.

The removal of atoms of iron or steel is more often successful than if the foreign body be of some other substance; for, in these cases, the magnet renders valuable aid, and makes it unnecessary that the foreign bodies should be visible, if they have been localised by the X Rays. And even localisation with the X Rays may be foregone, where, in a quite recent case, it is important there should be no delay in removing the foreign body. Fig. 179 represents Snell's Electro-magnet in two-thirds its actual size. It is a core of soft iron, around which is placed a coil of insulated copper wire, the whole enclosed in an ebonite case. To one extremity of the instrument are attached the screws to receive the connections of a small accumulator. At the other extremity the core projects just beyond the ebonite jacket, and is tapped, and into it screws the point. Points of various kinds or shapes can be adjusted to the magnet, according to the case to be dealt with. A point adjusted to the magnet having been passed through the sclerotic opening, it is advanced towards the foreign body, when the latter adheres to it, and is withdrawn towards the wound. Much care is required in drawing the foreign body through the opening, lest it be rubbed off the point in its passage. A forceps is generally used at this part of the proceeding, either to dilate the wound, or to seize the foreign body and extract it. As short and large a point as is consistent with the particular case should be employed, so that the greatest possible power of attraction may be obtained. A quart bichromate battery, or the street current, is used. When the foreign body is embedded in the coats of the eye at the back, or in a mass of inflammatory effusion, or is entangled in the ciliary region, difficulty or failure in the extraction is likely to be encountered. When a traumatic cataract is present, it is well

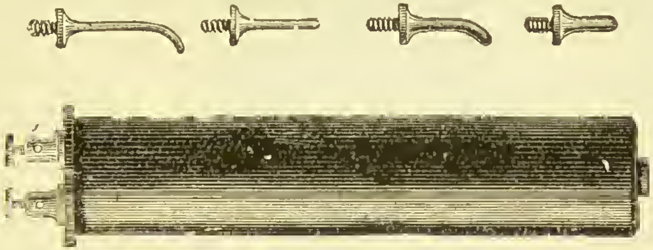
FIG. 179.

to combine its extraction with that of the foreign body, which latter is fetched out through the cataract incision with the magnet.

Haab's Giant Electro-Magnet (Fig. 180) is also used for extracting morsels of iron or steel from the eye. It is an immense and very powerful magnet, which is placed close to the eye. Care is required in its use, lest even more injury be done to the delicate tissues of the eyeball by the foreign body in its passage towards the magnet, than by its entrance into the eye. As a rule, it is recommended that the centre of the cornea, in the first instance, be brought opposite and close to the point of the magnet; for, by so doing, entanglement of the foreign body in the ciliary processes, from which it is not easy again to disengage it, may best be avoided. Foreign

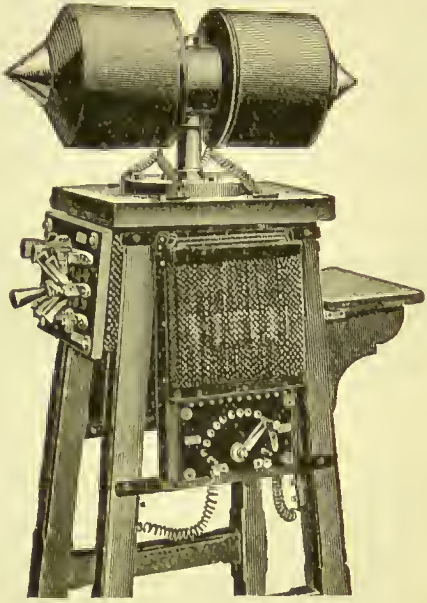

FIG. 180.

bodies which are in the vitreous humour, or which are not too firmly fixed in the retina, slide round the lens and bulge the iris forwards. As soon as this occurs the current is turned off, and the patient's head withdrawn from the magnet. By a suitable turning of the patient's head and eye, the latter being again approached to the magnet and the current turned on, the foreign body is drawn from behind the iris, through the pupil, which has been well dilated with atropine and cocaine, and into the anterior chamber. Should it not be possible to get the foreign body away from behind the periphery of the iris with the magnet, an iridodialysis may be formed with a keratome, and the foreign body drawn away with a Snell's magnet or with a forceps. It must not be attempted to draw the foreign body by the magnet through the iris, or else the latter may be partially or entirely pulled away. Having got the foreign body into the anterior chamber through the pupil, an incision with a Græfe's knife is made in the cornea, if possible without allowing the aqueous humour to flow away, and through the incision the sharp point of the giant magnet is passed, and the foreign body extracted. Even foreign bodies which enter through the sclerotic are best removed through the anterior chamber. When the foreign body is firmly fixed, it may often be loosened by turning the current rapidly on and off, or it may first be drawn towards the equator, and then towards the anterior chamber.

Cysticercus in the Vitreous Humour was not until recently very rare in some parts of Germany, but there have not been many such cases observed in the British Isles.

The original seat of the entozoon is usually beneath the retina (see chap. xvi.), through which it breaks to reach the vitreous humour; but it also sometimes makes its first appearance in the vitreous. It is recognised by its peculiar somewhat dumb-bell shape, its iridescence, and its peristaltic motions. The vitreous humour often becomes full of peculiar membranous opacities, as a consequence of the presence of the cysticercus.

Treatment.—Removal by operation. The prospects for the eye are very much worse than in the case of a sub-retinal cysticercus.

* **Blood Vessels** are sometimes formed in the vitreous humour. They spring from the retinal vessels, often in connection with connective tissue formations which accompany hæmorrhages ; but sometimes small loops arise in the neighbourhood of the disc, without any hæmorrhagic disease.

* **Persistent Hyaloid Artery.**—In intra-uterine life the hyaloid artery is a prolongation of the central artery of the retina, and runs from the papilla to the posterior surface of the crystalline lens. It completely disappears prior to birth, except in those rare cases where it remains as an opaque string, which may stretch the whole way from papilla to lens, or may extend only part of the way. It is then thrown into wave-like movements by the movements of the eyeball, and is easily recognised with the ophthalmoscope. It does not usually cause any disturbance of vision.

CHAPTER XVI.

DISEASES OF THE RETINA.

Diseases of the Retina may, for the purpose of description, be conveniently grouped as follows :—Alterations in Vascularity, Inflammation, Atrophy and Degeneration, Diseases of the Blood Vessels, Injury by Strong Light, Tumours, Parasitic Disease, Detachment, and Traumatic Affections.

ALTERATIONS IN THE VASCULARITY OF THE RETINA.

***Hyperæmia** and **Anæmia** of the retina, due to changes in the capillary vessels, cannot be seen with the ophthalmoscope, hence these terms are used to denote apparent enlargement or diminution of the principal branches of the central vessels. *Venous Engorgement* may occur as a local condition, as in papillitis, retinitis, thrombosis of the central vein, or as part of general venous obstruction in cardiac and pulmonary diseases. *Contraction of the Arteries* may also be due to local disease of the vessels (embolism, albuminuric retinitis, etc.) and spasm (malaria, quinine), or, more rarely, to diminished blood supply from general causes (cholera). The opposite conditions, namely, diminution in the size of the veins, and enlargement of the arteries, are rarely noticeable.

INFLAMMATIONS OF THE RETINA : RETINITIS.

*Retinitis, in general, is characterised by the following ophthalmoscopic appearance : *diffuse cloudiness*, especially of the central portion of the fundus, due to loss of transparency in the retina, and consequent veiling of the choroid; the *optic papilla* becomes more or less congested, with indistinctness of its outline, which in the erect image resolves itself into a delicate striation; *vascular engorgement*, the retinal veins especially becoming enlarged and tortuous. The inflammation in some cases may subside at this stage, but as a rule *hæmorrhages* and whitish *exudations* soon make their appearance.

The various forms of retinitis are distinguished by the predominance of some of the above signs, and also by the peculiar appearance and grouping of the exudations.

If the optic papilla be not merely congested, but also swollen, the condition is called Neuro-Retinitis.

In some cases of retinitis the choroid is also involved, and to these the name Chorio-Retinitis is given.

Inflammation of the retina is rarely a local affection, being in most cases due to general diseases, and hence it commonly occurs in both eyes.

***Syphilitic Retinitis** (or Syphilitic Chorio-Retinitis).—Inherited or acquired syphilis is liable to induce a form of chronic diffuse retinitis. In the acquired disease it is a later secondary symptom, coming on between the sixth and eighteenth month, often only in one eye.

With the Ophthalmoscope a slight opacity of the retina is seen extending from the papilla some distance into the retina, and very gradually disappearing towards the equator of the eye. The papilla is but slightly hyperæmic, while its margins are indistinct, like those of the moon seen through a light cloud. The artery is not generally altered, and the vein is but slightly distended. Opacities in the vitreous humour are not uncommon. They may be membranous or thread-like, but a diffuse dust-like opacity, filling the whole vitreous humour, is almost pathognomonic of a syphilitic taint (p. 495), and may create much difficulty in the ophthalmoscopic diagnosis of the retinal affection.

Disseminated chorioidal changes, in the form of small yellowish spots with pigmentary deposit, are very frequent, especially towards the equator of the eye. Many observers, indeed, hold that the whole process is primarily in the chorioid, and that the retina is only secondarily affected. Fine whitish dots and pigmentary changes often occur about the macula lutea.

Occasionally, instead of the diffuse retinitis, syphilis causes a circumscribed yellowish white exudation in the neighbourhood of the macula lutea, or on the course of one of the large retinal blood-vessels. (See also p. 515.)

Vision may be but slightly affected, but in the advanced stages it is usually much lowered. Central, or peripheral, or ring scotomata, or concentric defects of the field, are found. The scotomata are often positive—*i.e.*, they can be seen by the patient as dark spots in the field. Night-blindness is a constant symptom, and the light-sense is enormously diminished. The patients sometimes complain of sparks or lights, which seem to dance before their eyes, and occasionally also of a diminution in the size (micropsia) of objects, or of a distortion (metamorphopsia) of their outlines. The micropsia is believed to be due to a separation from each other of the elements of the layer of rods and cones by sub-retinal exudation. The image of an object then comes into relation with fewer of these elements, and hence the mental impression is that of a smaller object than is conveyed by the image formed in the sound eye, or on a sound part of the same retina.

The Progress of the Disease is very slow, and is liable to relapses. In the late stages extensive pigmentary degeneration of the retina may come on, or disseminated chorioiditis. But if the cases come under suitable treatment in an early stage, a cure may often be effected.

Treatment.—The only remedy which is of real value is mercury, and that in an early stage. It should be used in a protracted course of some weeks by inunction, combined at discretion with small doses of calomel internally. Or, the method by intra-muscular injection of mercury may be used. If mercurialisation be effected, it should not go further than a very slight stomatitis. Turkish baths, and the artificial leech at the temple, may be employed as adjuncts to the treatment. When the mercurial course has been completed, iodide of potassium should be prescribed as an after-treatment. Complete rest of the eyes, and protection from strong light by dark glasses, are also necessary in this, as in many forms of retinitis.

***Hæmorrhagic Retinitis.**—In this affection the retina contains a number of small hæmorrhages. They occur chiefly between the fibres of the inner layer, and consequently present a flame-like appearance as seen with the *Ophthalmoscope.* Any which lie in the outer layers are more apt to be round or irregular in shape. In addition to the hæmorrhages, there is diffuse opacity of the retina, and sometimes white spots of degeneration. The papilla is often much swollen, and the retinal veins distended and tortuous, while the arteries are small; but these appearances, as well as the number of the hæmorrhages, vary much in different cases. When there are but few hæmorrhages, they are situated in the neighbourhood of the papilla and macula lutea. The appearances occasionally resemble those of albuminuric retinitis, but in the latter, as a rule, the proportion of white spots to hæmorrhages is greater than in this affection. Probably many cases regarded as hæmorrhagic retinitis are due to thrombosis of the central vein. (See p. 526.) In a small proportion of cases glaucoma (p. 447) comes on.

Causes.—The affection is found most commonly in connection with cardiac disease—*e.g.*, valvular insufficiency, and hypertrophy of the left ventricle; or with diseases of the vascular system—*e.g.*, atheroma, and aneurisms of the large vessels. Where it is due to disease of the coats of the arteries, the ophthalmoscope will occasionally reveal an arterial branch altered to the appearance of a white thread; but usually the degenerative change does not interfere with the transparency of the vascular coats. In the majority of cases dependent on cardiac or vascular disease the retinal affection is monocular. This, and the frequently sudden onset of the retinitis, suggests some second factor for its occurrence, probably multiple embolisms of the small branches of the central artery. Suppression of menstruation, or other wonted discharge—such as that from piles—has been observed as an immediate cause of hæmorrhagic retinitis.

A peculiar form of hæmorrhagic retinitis is sometimes associated with secondary syphilis. In addition to the usual opacity of the retina in syphilitic retinitis (p. 512), a portion of the retina is covered with numbers of small round hæmorrhages lying in the different layers of the retina, while a connective tissue development is occasionally found in the nerve-fibre layer, in the form of white striæ along the course of the blood-vessels.

The disturbance of vision is considerable, especially if the neighbourhood of the macula lutea be much involved.

The Prognosis is unfavourable in severe cases of hæmorrhagic retinitis. Relapses are common, while the ultimate tendency is towards atrophy of the retina and papilla. In very mild cases recovery may come about.

The Treatment must be chiefly expectant, or directed, at most, towards procuring rest for the general system, or for the organ primarily at fault. Dry cupping on the temple, hot foot-baths, and iodide of potassium internally may be employed.

Retinitis Albuminurica occurs as a complication in many cases both of acute and chronic nephritis, and in the albuminuria of pregnancy. It is most common with the small granular kidney, but may attend any chronic form of Bright's disease, and occurs in 6 or 7 per cent. of these cases.

The Defect of Vision in the chronic form, although often the first symptom which causes the patient to seek advice, is never associated with an early stage of the kidney disease, but rather with a late stage of it, and with dilated left ventricle. Both eyes as a rule are affected, although often not equally so. Vision is much lowered, and even perception of light may be wanting; but the blindness is not always all due to organic changes in the retina, being often largely the result of uræmia. (See Uræmic Amblyopia, chap. xx.)

Ophthalmoscopic Appearances.—These are venous hyperæmia, with swelling of the papilla, and of the retina in its neighbourhood; hæmorrhages on the papilla, and in the nerve-fibre layer of the retina; and round or irregularly shaped white spots in the retina, arranged in a zone around the papilla, some three papilla diameters removed from it. These changes take place in the order enumerated. The hyperæmia and engorgement of the veins, often very great, become less, according as the white spots become more developed. Near the macula lutea no very coarse changes usually occur; but fine white dots are found, with a star-like arrangement converging towards the macula. In some cases the spots spread out only on the inner side of the macula towards the papilla. The degree in which all these different changes are present varies in different cases, no one of them being pathognomonic of the kidney affection, but rather the grouping of the whole picture being suggestive. Sometimes the papillitis is so intense as to simulate that formerly known as congestion papilla in cases of intracranial tumour; while the white spots are sometimes developed to such a degree as to become confluent, and to form one large white plaque. Again, the papillitis, or white spots, or both, may be but slightly marked. The number and size of the hæmorrhages are also liable to great variation. Detachment of the retina has been observed in a few cases; and in some the hæmorrhages burst into the vitreous humour.

Some of the white spots are caused by fatty degeneration of the outer layers of the retina (the retinal vessels passing over them), others by hypertrophy of the nerve-fibre layer (the retinal vessels hidden by them). The fine dots about the macula lutea are the result of fatty degeneration of the inner ends of Müller's fibres. Small aneurismal dilatations of the arteries occur very occasionally, and detachment of the retina is sometimes seen.

The connection between the renal and retinal affections is not known with certainty, but the theory that the latter is due to chronic uræmia is probably correct.

Prognosis.—In chronic cases the prognosis as regards the patient's life is bad. The majority die within eighteen months or two years; but, if the general disease remain stationary, or improve, or recover, the retinal changes may improve or disappear, and may leave the retina with normal appearances and functions; or the swelling, hyperæmia, white spots, and hæmorrhages may give place to optic atrophy, with diminution in size of the arteries, pigmentary alterations in the retina, and blindness. In the albuminuria of pregnancy, and in acute nephritis, the retinal complication may disappear with the renal disorder, leaving good vision.

Treatment.—No treatment other than that for the primary renal disease is of avail. Taking into consideration the serious import of this eye-symptom for the life of the patient, it is a question whether, in many cases of pregnancy with albuminuric retinitis, abortion should not be resorted to, especially if the pregnancy have still some months to run. But on the whole the prognosis is more favourable in the albuminuria of pregnancy than in interstitial nephritis.

Retinal Affections in Diabetes.—There is no one condition of the retina characteristic of diabetes, although undoubtedly retinal affections occasionally do complicate it in an advanced stage. Small retinal hæmorrhages, with fine changes in the form of glistening dots, about the macula lutea, somewhat similar in appearance to those which occur in Bright's disease, except that they rarely form the well-marked star, are perhaps the most common and suggestive appearances. In other cases retinal hæmorrhages alone are found, and in others hæmorrhagic retinitis; while, again, the so-called typical appearances of Bright's disease may be presented. There are often opacities of hæmorrhagic origin in the vitreous humour, and iritis may come on.

It is an important rule of practice that, in all cases of retinal hæmorrhages and of retinitis hæmorrhagica, the urine should be examined for sugar and albumen.

***Retinitis Leucæmica.**—In not more than one-third or one-fourth of the cases of leucocythemia, or pseudo-leucæmia, does a retinal affection occur, and it is not always of the same type. It may consist in a slight diffuse retinitis, accompanied by some extravasations of pale blood; while the blood vessels are also pale, the veins being much enlarged, and rather flattened than over-distended, the arteries small, and the chorioid of an orange-yellow colour. Or, it may resemble a case of ordinary hæmorrhagic retinitis.

The Appearances most characteristic of the affection are: a pale papilla with indistinct margins; slight opacity of the retina, especially along the vessels; small hæmorrhages: round, white, elevated spots up to 2 mm. in diameter, with a hæmorrhagic halo, situated by preference towards the periphery of the fundus and at the macula lutea, but not at all, or only in very severe cases, in the zone between the macula and the equator of the eye. These white spots consist of extravasations of leucæmic blood, the result, probably, of diapedesis.

Vision may be but little affected if the macula lutea be fairly free. Hæmorrhage into the vitreous humour may cause complete blindness.

***Development of Connective Tissue in the Retina**, or **Retinitis Proliferans.**—Extensive white striæ, formed of connective tissue, are sometimes seen in the retina, and may even conceal the vessels and papilla. They often protrude into the vitreous humour, and contain newly formed vessels, which are prolongations of the retinal vessels. These striæ are the result of hæmorrhages, traumatic or otherwise, and of inflammatory processes, and are formed by proliferation of Müller's fibres, and by new growth of connective tissue. Hæmorrhages in the retina, or in the vitreous humour, or in both, are generally present at some period. Vision is often but slightly affected, but the danger of recurrent intraocular hæmorrhages renders the ultimate prognosis unfavourable as a rule.

Treatment.—Heurteloup's leech. Iodide of potassium, or perchloride of mercury. Protection spectacles.

* **Retinitis Circinata** is a rare disease. It occurs in old people, chiefly women, and is characterised by very remarkable appearances. At the macula is a grey or yellowish cloudy patch, which may attain the size of the papilla, and sometimes presents hæmorrhages on its surface; surrounding this, but separated from it by a healthy zone, is a ring composed of numerous, closely set, small white spots, which are confluent in places. The sight gradually becomes much deteriorated. A large central scotoma develops, and vision is finally reduced to finger-counting centrally, although for a long time the peripheral field may not become contracted. Total blindness rarely results.

***Purulent Retinitis** is observed as the result of septic embolism of the retinal arteries in septicæmia after surgical operations, etc., and very frequently in cases of metria, and it is usually, in the latter condition, a fatal sign. In an early stage the ophthalmoscope shows a number of small hæmorrhages in the retina, with general cloudiness of the retinal tissues, while the actual embolisms, which are usually multiple, may not be visible. The inflammation makes rapid progress, soon destroying sight, and extending to the chorioid, iris, and vitreous humour, until finally panophthalmitis is reached. The retina is sometimes alone the primary seat of the embolic attack, and sometimes the chorioid is also involved. The embolisms are often little more than masses of micrococci.

The retina, of course, becomes secondarily implicated in many purulent processes, which commence in other parts of the eye.

ATROPHIES, AND DEGENERATIONS, OF THE RETINA.

***Retinitis Pigmentosa** is a degenerative, rather than an inflammatory, affection of the retina. It is extremely chronic in its progress, coming on most commonly in childhood, and often resulting in complete, or almost complete, blindness in advanced life.

Vision is much affected, but the symptom most complained of is night-blindness, due rather to defective power of retinal adaptation than to defective light-sense. The field of vision, moreover, becomes gradually contracted, until only a very small central portion remains ; so that, although the patient may still be able to read, he cannot find his way alone—a function for which the eccentric parts of the field are the most important. A ring scotoma in the field of vision is present in some cases. Finally, the last remaining central region becomes blind.

The Ophthalmoscopic Appearances consist in a pigmentation of the nerve-fibre layer of the retina, which commences in the periphery, but not at its extreme limits, and in the course of years advances towards the macula lutea. The pigment is arranged in stellate spots, of which the processes intercommunicate, so that the appearance reminds one of a drawing of the Haversian system of bone. Pigment is also deposited along the course of many of the vessels, hiding them from view. The degree of pigmentation varies much, and in some cases is quite absent, and the diagnosis then has to depend upon the other appearances and on the symptoms, The papilla is of a greyish-yellow colour, never white, and the vessels are very small.

The chorioid is sometimes slightly affected, irregularity in its pigmentation being observable. At the posterior pole of the crystalline lens there is often a star-shaped opacity. (p. 461).

Pathology.—The pigment in the retina is believed to wander into it from the pigment-epithelium layer. The other pathological changes in the retina consist in hyperplasy of its connective tissue elements, and thickening of the walls of the vessels at the expense of their lumen.

The chorioidal vessels, too, are altered, owing to endarteritis, which causes hypertrophy of their coats, with more or less obliteration of their lumen. In fact, it seems probable that the primary seat of the diseased process is in the chorioid; and, that it is the changes in it which cause the pigment from the pigment-epithelium layer to wander into the retina.

Causes.—Retinitis pigmentosa often affects more than one member of a family; and the patients, too, are frequently defective in intelligence, or deaf and dumb. Many of them are the offspring of marriages of consanguinity, and in others an inherited syphilitic taint is present, while in others no cause can be assigned. Other congenital defects, supernumerary digits, etc., are sometimes present.

Treatment is of little use. At best one may stimulate the torpid retina temporarily by hypodermic injections of strychnia, or by the continuous current.

***Retinitis Punctata Albescens.**—This disease commences in early childhood, or is perhaps congenital. It often occurs in more than one member of a family, and the parents are frequently blood-relations. The main symptom is night-blindness; in good daylight central vision is usually not defective to any marked degree. The field of vision is contracted. Ophthalmoscopically, the fundus, with the exception of the macula lutea and its immediate neighbourhood, is sprinkled over with innumerable small white dots, which, for the most part, are free from any pigmentary disturbance in their neighbourhood. In some cases, towards the periphery of the fundus, signs of chorioidal atrophy are present, or, there may be pigment in the retina there. The retinal vessels and the optic papilla are unchanged. It is thought by some that this disease is related to retinitis pigmentosa.

Treatment is of no avail.

***Gyrate Atrophy of the Retina and Chorioid.**—This disease, which is rare, is apt to occur in more than one member of the same family, and in children whose parents are blood-relations. The first symptom appears in childhood as night-blindness. The optic papilla is atrophied, as in retinitis pigmentosa, and atrophy of the retina is shown by the narrowing of its vessels. The characteristic feature is the peculiar form of chorioidal atrophy. In a zone with the papilla for its centre, and extending nearly to the latter, white atrophic dots with sharp margins form, and gradually increase in size, until they become confluent. The atrophy involves both the pigment epithelium, and the stroma of the chorioid. The papilla is finally surrounded by a broad white girdle, from which it is separated by a band of normally coloured fundus. The edge of the girdle towards the papilla is scalloped, because the separate rounded parts of which it is composed extend backwards in varying distances, while the remains of the normal fundus project forwards between them in sharp processes. There is often, as in retinitis pigmentosa, a star-shaped posterior polar cataract. In addition to the night-blindness, central vision is much lowered, even in good light, and the field of vision is much contracted. This disease, too, is closely related to retinitis pigmentosa.

DISEASES OF THE RETINAL VESSELS.

***Apoplexy of the Retina.**—This differs from hæmorrhagic retinitis, in that the hæmorrhages are found in a retina free from other diseased appearances, retinitis in particular.

With the Ophthalmoscope the extravasations of blood appear as red, or almost black, spots of various sizes and shapes. Their number and position in the fundus are also variable. They may be in any layer of the retina, and sometimes burst into the vitreous humour, and sometimes become extravasated between the retina and chorioid.

Vision is interfered with according to the position and extent of the hæmorrhages. Wherever an apoplexy be situated, the function of the retina at that place is suspended. If it be at the macula lutea, central vision will be seriously impaired; while the scotoma produced by an apoplexy at the periphery of the fundus may pass unnoticed by the patient.

Causes.—Retinal apoplexies are due to atheromatous disease of the vessels, which affects the retinal vessels as well as those of the general system; local disease of the retinal vessels, as in high myopia; altered states of the blood, as in pernicious anæmia, purpura, and other exhausting diseases; hypertrophy of the left ventricle; suppression or irregularity of menstruation, or at the climacteric period; the sudden reduction of tension of the eyeball after iridectomy for glaucoma; the gouty diathesis (Hutchinson); and thrombosis of the retinal veins is often the immediate cause. Retinal apoplexies are most common in advanced life, with atheroma of the blood-vessels, and are then valuable as a warning of possibly impending mischief.

In young people of both sexes, from the fourteenth to the twentieth year of age, large retinal apoplexies, which may extravasate into the vitreous humour (p. 498), are sometimes seen, and it is difficult to assign a cause for them. Some of the subjects are weak or anæmic, while many of them are in perfect health.

Prognosis.—The apoplexies are observed, in the course of weeks or months, to become paler and smaller, often leaving after them chorioidal changes, or greyish spots dependent on degeneration of the retina, and in some extreme cases atrophy of the whole retina may result.

Occasionally, absorption of the hæmorrhages is accompanied by complete restoration of vision, but usually the scotomata remain. Recurrences of the hæmorrhages are very common. Glaucoma comes on as consecutive to retinal apoplexies in some instances, and is then known as hæmorrhagic glaucoma, an incurable form of the disease (p. 447). In other cases the hæmorrhage, having invaded the vitreous humour, gives rise to dense permanent opacity in it, followed, perhaps, by detachment of the retina.

Treatment.—Active measures are of little use. Cold compresses at first, with a pressure bandage, and dry cupping to the temple, may be employed. The general state of the patient must be attended to, with rest of the body. Some oculists have found much advantage from subconjunctival saline injections.

***Embolism of the Central Artery of the Retina.**—Sudden or very rapid blindness, beginning at the periphery of the field, and advancing towards the centre, is the only symptom experienced by the patient.

Immediately after the attack, the *Ophthalmoscope* shows a marked pallor of the papilla, while the artery and its branches are empty of blood, resembling fine white threads, and the veins are diminished in size at the papilla, but somewhat increased in size towards the periphery. Pressure on the eyeball produces neither pulsation nor change in calibre of the vessels, as it does in a sound eye. Usually, on the following day, the central region of the retina begins to assume a greyish-white opaque appearance, consequent on œdema of the nerve-fibre layer, in the midst of which the macula lutea is seen as a cherry-red spot. The little blood contained in the vessels may soon be observed to divide into short columns with colourless interspaces, and these short columns move along the vessels with a slow jerky motion. Minute hæmorrhages often occur, most commonly between the macula and the papilla.

The cherry-red spot at the macula lutea is not due to hæmorrhage. It is probably a contrast effect, the red colour of the chorioid shining through, where no nerve-fibre layer is present; or, possibly, it may be due to the retinal purple.

The œdema of the retina passes away in a few weeks, and also the peculiar appearance of the macula lutea, while atrophy of the retina and papilla usually supervene.

Embolism of a branch only of the central artery has been observed. In these cases the infiltration and the defect of vision are confined to the part of the retina supplied by the embolised branch.

Prognosis.—Vision may improve for a time, but when atrophy commences it falls back again; and, finally, power of perception of light is lost. Cases of embolism of a branch of the central artery are more likely to recover.

Causes.—Endocarditis; mitral disease; atheroma of the large arteries of the body; aneurism of the aorta; pregnancy; Bright's disease. Two cases of chorea with embolism of the central artery are recorded. But it is said to occur also in healthy persons, without any discoverable cause.

Treatment.—Repeated paracentesis of the anterior chamber has been tried, and also iridectomy, with the object of reducing the tension, and in this way promoting a collateral flow of blood, by means of the only ascertained communications between the retinal and chorioidal vascular systems—namely, at the entrance of the optic nerve. These attempts have been unsuccessful.

Several cases have been published, in which the circulation, which probably was not completely impeded by the embolus, was restored, and good vision regained; the recovery being probably due to the manipulations of the eyeball made in each case for the purpose of observing the effect of pressure on the vessels. So long as the pressure was maintained, a column of blood was being stored up behind the embolus, and, on removal of the pressure, it rushed forward against the impediment, carrying the latter into some more remote vessel, or into the general vascular system. In fresh cases, massage of the eyeball suitably applied would, therefore, always be worth the trial.

*__Thrombosis of the Retinal Artery.__—Blocking of the artery may occur spontaneously, from thrombosis due to failure of the heart's action and slowing of the arterial flow, the result, in its turn, of cardiac disease, spasm of the blood vessels, disease of the walls of the vessels, or alterations in the quantity and amount of blood.

The *Ophthalmoscopic Signs* are in all respects similar to those of embolism.

The *Diagnosis* between thrombosis and embolism of the central artery can only be made by certain symptoms, which precede or accompany the attack in thrombosis, but are wanting in embolism. These are: previous attacks of transient blindness in the blind eye, a simultaneous attack of blindness in the fellow eye, and faintness, giddiness, and headache at the onset of the blindness.

Treatment.—When transient attacks of blindness are complained of, it is important to overhaul the patient's general state, and to correct, so far as possible, any condition which might be the cause of feeble circulation. When the true attack comes on, manipulation of the eyeball applied immediately, or paracentesis of the anterior chamber, might prove of use.

*__Thrombosis of the Retinal Vein__ is seen chiefly in old people with atheromatous arteries or cardiac troubles. Orbital cellulitis, from erysipelas or other causes, may also produce it.

The Ophthalmoscopic Appearances are: extreme engorgement of the retinal veins, with great narrowing of the arteries; the whole fundus is thickly studded with dark hæmorrhages; the optic papilla after a time becomes pale, and undergoes atrophy, and the hæmorrhages, having become absorbed, leave an atrophied retina with thready arteries.

The Prognosis is very bad, sight becoming permanently damaged or lost, and *Treatment* can only be directed to the general condition.

***Sclerosis of the Retinal Vessels** (Perivasculitis, or, more rarely, Endarteritis) reveals its presence by narrowing of the blood column, and by the appearance of white lines along the vessels. It usually begins in the large trunks on the papilla, and may not extend much beyond the latter, as in some cases of optic atrophy; while in other cases (Bright's disease, hereditary syphilis) it involves the small branches as well, and promotes thrombosis and retinal apoplexies, and may even ultimately lead to obliteration of the lumen of the vessels, so that they look like white branching streaks. The arteries are more liable to this condition than the veins.

Quinine Amaurosis.—Quinine in large doses, and very occasionally in small doses, is liable in some individuals to cause amblyopia, which may come on almost suddenly, and may amount to absolute blindness, accompanied for some hours or days by great deafness. This absolute blindness is rarely more than temporary, although it may last for some weeks—indeed, there is only one case of permanent quinine amaurosis on record; but, in severe cases, concentric contraction of the field is apt to remain permanently, with or without some defect of central vision. In a serious instance, the colour and light-senses, notwithstanding the contracted field and marked seeming optic atrophy, were normal; but the adaptation of the retina, as shown by considerable night-blindness, was defective.

Yarr finds that doses of sulphate of quinine of more than 20 grains are dangerous to the sight, and that more than 40 grains should not be given in twenty-four hours. During the early stages, the pupils are widely dilated, and the cornea and conjunctiva are sometimes anæsthetic.

In what may be called the acute stage, the *Ophthalmoscopic Appearances* are sometimes normal, but pallor of the optic papilla, with scarcity and smallness of the retinal vessels, is the more usual condition. Where the case is chronic—the fields remaining contracted, although central vision has improved—the ophthalmoscope may discover a very pale optic papilla with minimal vessels.

The retinal ischæmia is doubtless the immediate *Cause* of the amblyopia, and is the result of diminished heart's action and lowered arterial tension, both of which have been shown to be produced by large doses of quinine. Destruction of the ganglion cells of the retina towards its periphery has been found, and to it may be referred the permanent contraction of the field of vision in some cases.

Treatment.—Cessation of the use of quinine. Digitalis internally to raise the arterial tension, nitro-glycerine, hypodermic injections of strychnia, and general tonic treatment. Yarr has found that nitrite of amyl causes only temporary improvement of vision.

***Amaurosis from Filix Mas.**—In the rare cases of this kind due to large doses (ʒj to ʒij) of extract of male fern, great diminution in calibre of the retinal arteries with congestion of the veins, and extreme œdema of the retina, seem to be the initial appearances, followed at a later period by atrophy of the optic nerve. In severe cases vision does not return.

INJURY OF THE RETINA BY STRONG LIGHT.

***Blinding of the Retina by Direct Sunlight.**—This is especially likely to occur on the occasion of solar eclipses, by observation with unprotected eye.

Immediately after the exposure, the patients complain of a dark or semi-blind spot in the centre of the field of vision—a positive scotoma, in short, which may even be absolute, and which interferes with vision in proportion to the length of the exposure. There may also be a central defect for colours, which may extend over a larger area. A peculiar oscillation, or rotatory movement, is frequently observed by the patient in the scotoma, and is very persistent. Objects may also seem twisted or otherwise distorted (metamorphopsia).

The Ophthalmoscopic Appearances may be normal, but as a rule some changes exist, such as an alteration or loss of the light reflex at the macula, or a minute pale orange spot near the fovea, with, especially in the later stages, some darkening or pigmentation. When the cases are not severe, improvement in vision takes place, but complete recovery is not common. Hitherto no case in which the vision had been reduced to less than $\frac{1}{3}$ has regained .

Treatment.—Hypodermic injections of strychnia, the constant galvanic current, dry cupping on the temple, and subconjunctival saline injections, afford the best chances for promoting the cure. Rest, and dark protection glasses, are important.

***Snow-Blindness.**—Exposure of the unprotected eyes for a length of time to the glare from an extensive surface of snow produces, in some persons, a peculiar form of ophthalmia, which may be followed by temporary or even permanent amblyopia. Although this condition is chiefly an affection of the conjunctiva, it is described here in order to compare it with the effects of sunlight and electric light.

Snow-blindness begins with sensations of a foreign body in the eye, photophobia, blepharospasm, and lacrimation ; later on chemosis, with small opacities, or ulcers, of the cornea, comes on. The condition passes off in three or four days without leaving any permanent ill results, except in rare cases, when there may be some secondary hyperæmia of the retina. It is held to be the ultra-violet rays which cause snow-blindness.

Treatment.—The preventative treatment consists in the wearing of dark smoked glasses when travelling on the snow; while for the ophthalmia cold applications and cocaine are recommended, to relieve the distressing symptoms.

***Effects of Electric Light on the Eyes.**—The degree of intensity of light required to produce injurious effects on the eye is not known ; but it is certain, that no bad results have been observed from the ordinary use of the incandescent electric light, for reading, writing, etc. ; on the contrary, it may be regarded as the best artificial light for these and other domestic uses. It has a greater illuminating power, produces less heat and no products of combustion, and hence it does not vitiate the atmosphere, or tend to cause conjunctival irritation. The electric light is much steadier than gas ; and, on account of the smaller quantity of red rays which it emits, it is a nearer approach to sunlight than gas, unless where the latter is used with the incandescent mantle. Two groups of symptoms are observed from the action of strong electric light on the eyes :—

(*a*) *Electric Ophthalmia.* This has been chiefly seen in those employed in electric welding operations, and less frequently in electricians who use strong arc-light. The symptoms begin shortly after exposure to the light, always within twenty-four hours, and are the same as those present in snow-blindness; the lids also are swollen, and even erythematous at times. The pupils are contracted. A slight muco-purulent secretion from the conjunctiva appears after the subsidence of the above symptoms. Recovery takes place in a few days, with complete restoration of vision, except in rare cases.

(*b*) *Blinding of the Retina.* This is the same affection as the blinding of the retina by sunlight. The central scotoma may persist after an attack of electric ophthalmia, or may occur without it. The injurious action of the electric light on the eye has been attributed to the chemical action of the ultra-violet rays, to the accompanying heat rays, and to dazzling of the retina. Widmark's experiments show that changes can be produced in the retina by the electric light, without any heat coagulation. These changes consist in œdema, with more or less destruction of the nervous elements of the retina—namely, the outer layers, including the rods and cones, and the inner layer of nerve fibres.

Treatment.—The preventive treatment consists in the use of coloured glasses. Yellow glass has been recommended by Maklakoff. In the electric welding works in Germany a combination of deep blue and red is used, while the Sheffield workers prefer several layers of ruby glass. For the rest of the treatment see the paragraphs on snow-blindness, and blinding by sunlight.

TUMOUR OF THE RETINA.

* **Glioma of the Retina.**—This is a malignant growth and is found almost exclusively in young children, or may even be congenital. It is sometimes in each eye. Owing to the age of the patients, the incipient stages of the disease are seldom observed, for they are unattended by pain or inflammation.

The growth commences as small, white, disseminated swellings in the retina, usually in one or other of the granular layers, more rarely in the nerve-fibre layer. The retina is apt to become detached at an early period; but there are exceptions to this, especially when the disease starts from the nerve-fibre layer. In the early stages there is no iritis, cyclitis, or opacity of the vitreous humour, and the iris periphery is not retracted—points which especially enable us to distinguish it from pseudo-glioma (p. 494). Secondary glaucoma finally comes on. The optic nerve may become involved at an early period; but sooner or later it invariably does so, leading then by extension to glioma of the brain. When the tumour has filled the eyeball, it bursts outwards, usually at the corneo-sclerotic margin, and then grows more rapidly, and often to an immense size, as a fungus hæmatodes. The orbital tissues become involved, and even the bony walls of the orbit; while secondary growths in other organs, more especially in the liver, are not rare.

The diagnosis between glioma of the retina and tubercle of the chorioid (p. 403), when the latter occurs in young children, is sometimes difficult or impossible; but, in view of treatment, it is not of great importance, as in either case the eye must be enucleated.

Treatment.—The only hope of saving the patient's life lies in enucleation at an early stage, or before the optic nerve becomes diseased. It is important in removing the eyeball, as in every intraocular growth, to divide the nerve as far back as possible; and, if the orbital tissues be already diseased, to remove all suspicious portions of them. Several cases in which there was no return of the growth have been observed, even after removal of both eyes.

* **Tubercle of the Retina.**—Primary tubercle of the retina is exceedingly rare, and presents the appearance of a more or less extensive and slightly elevated white area, at the posterior pole of the eye, involving the optic disc or macula lutea or both. When the disease occurs in a young child, the diagnosis from glioma of the retina will present difficulty. More commonly, tubercular disease of

retina is secondary to tuberculosis of the uveal tract, or optic nerve.

PARASITIC DISEASE.

* **Cysticercus under the Retina.**—The cysticercus of the tænia solium in the eye is very rare. Its most frequent seat is between the retina and chorioid, where it is recognised with the ophthalmoscope as a sharply defined bluish-white body, with bright orange margin. At one point of the cyst there is a very bright spot, which corresponds with the head of the entozoon. Wave-like motions along the contour of the cyst should be looked for to confirm the diagnosis. The cysticercus may move from its original position, and in so doing cause considerable detachment of the retina. Delicate veil-like opacities are apt to form in the vitreous humour, and are almost characteristic of the presence of cysticercus.

The entozoon may become encapsuled behind the retina; or it may burst into the vitreous humour (p. 504); and finally chronic irido-cyclitis, with total loss of sight and phthisis bulbi, is apt to come on.

Treatment.—There is no anthelmintic which will act upon the entozoon in the eye. Removal of the cyst by operation is the only means by which the eye can be saved; and this measure can only be resorted to when the position of the cysticercus is favourable—*e.g.*, when it is close to the equator of the eyeball. In such cases, by a well-placed puncture through the sclerotic and chorioid, the entozoon may be evacuated.

DETACHMENT OF THE RETINA.

This condition consists in a separation of the retina from the chorioid, the intervening space being occupied by a clear serous fluid. It is not usual to employ the term, when it is a solid neoplasm only that lies between retina and chorioid.

If the media be clear, and the detached portion extensive, the diagnosis is not difficult.

The Ophthalmoscope shows a greyish reflex from a position in front of the fundus oculi, and to the surface from which the reflex is obtained a wave-like motion is imparted when the eyeball is moved. Over this greyish surface the retinal vessels run, and they serve to distinguish a detached retina from any other diseased condition with a somewhat similar appearance. They seem black, not red, in consequence of absorption of the light reflected back from the fundus, and are hidden from view here and there in the folds of the detached retina. In many cases a rent in the detached retina, usually towards the ora serrata, through which the chorioid can be discerned, will be discovered.

The detachment may commence in any portion of the fundus, but most commonly does so above; yet, owing to gravitation of the fluid, it ultimately settles in the lower half of the fundus, and hence this is the most common place to find it, the part first detached having become replaced. The diagnosis is more difficult if there be but little fluid behind the retina, or if there be opacities in the vitreous humour.

Vision is affected according to the position and extent of the detachment. Central vision may be quite normal if the macula lutea and its immediate neighbourhood are intact. The patients complain of seeing objects distorted, of a black veil which seems to hang over the sight, and sometimes of black floating spots before the eye, due to opacities in the vitreous humour. These symptoms often come on suddenly in an eye which has hitherto had good sight.

The field of vision, on examination, will show a defect corresponding to the position of the detachment. If, for example, it be below, the defect will be in the upper part of the field. If the detachment be fresh, the retina not having yet undergone secondary changes, and if the quantity of sub-retinal fluid be not great, the defect in the field may only amount to an indistinctness of vision; while later on, when —owing to derangement of its nutrition from its being separated from the chorioid capillaries—infiltration and degeneration of the detached part come about, fingers may not be counted at the same place. The phosphenes[1] of the detached portion are wanting.

Should the detachment become complete, little more than mere power of perception of light may be present. Total detachment is followed by cataract, and often by iritis, cyclitis, and phthisis bulbi. The detachment may remain stationary, and not extend to the whole fundus, or the retina may return to its normal position; but such a happy event is most rare.

Causes.—Myopic eyes—which we know are so frequently affected with chorioiditis and disease of the vitreous humour —are those most subject to detachment of the retina (p. 58); but idiopathic detachment occurs also in eyes which are apparently healthy. Blows upon the eye may produce detachment, the retro-retinal fluid being serous or bloody. Some punctured wounds of the sclerotic, in the course of healing, by dragging on the retina, give rise to it. Chorioidal tumours, especially those situated in the posterior segment of the fundus, usually cause detachment in an early stage of their growth, and the complication renders their diagnosis more difficult (p. 402).

Leber observed that in non-traumatic detachment a perforation or rent in the detached portion is very frequently to be seen with the ophthalmoscope, and holds that it is probably always present, although sometimes, from being hidden behind a fold of the retina, it cannot always be found. He was led from this, and from his pathological investigations and experiments upon animals, to the opinion that the detachment was due to shrinking of a diseased vitreous, which first became slightly separated from the retina, and that then—at some place where the retina and hyaloid had become adherent by reason of the inflammatory process—a rent was produced in the retina by the shrinking process in the vitreous. He concluded that through this rent the fluid, which is always present behind the vitreous in cases of detachment of that body, makes its way behind the retina, and separates the latter from the chorioid. The suddenness with which detachment often comes on is accounted for by this theory. Nordenson's pathological researches went to corroborate this. He ascertained, too, that disease of the ciliary body and chorioid is the primary cause, although we may not be always able to detect it with the ophthalmoscope, and that the pathological change in the vitreous humour consists in an alteration in its connective tissue elements, resulting in the deleterious shrinking.

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[1] Phosphene is the subjective sensation of light experienced when the eyeball is pressed upon. For clinical purposes it is best tested by gentle pressure with a blunt point (head of a bodkin or large-sized probe) applied to the eyeball through the eyelid. The phosphene of any region is tested by applying pressure to that part of the globe. Thus, if in a healthy eye the individual look down, and pressure be applied to the upper part of the globe through the eyelid, the phosphene will be seen appearing below; but if there be a detachment of the retina at the place pressed on, no phosphene is seen.

Raehlmann, however, from the results of experiments, and also from clinical observation, concludes that detachment of the retina is due to exudation from the chorioidal vessels of a fluid, which is more albuminous than the fluid in the vitreous humour. Hence, he thinks, diffusion takes place through the retina, and a greater quantity of the less albuminous vitreous fluid passes through the retina, thus producing and increasing the detachment. Rupture of the retina is not, in his view, a necessary factor in the causation, but it may occur if the tension behind the retina be higher than that in front of it.

Treatment.—Evacuation of the subretinal fluid by puncture of the sclerotic was proposed by Sichel, and cultivated by de Wecker. The instrument used resembled a broad needle, with a sharp point and two blunt edges, which is entered through the sclerotic and chorioid at a place corresponding to the position of the detachment, but not so deeply as to reach the retina, lest thereby it be further displaced. The instrument is then given a quarter of a rotation, to make the wound gape, so as to admit of the flowing off of the fluid. If possible, a position near the equator of the globe, and between two recti muscles, should be selected for the operation. Moreover, the incision should lie parallel to the direction of the orbital muscles, so that the chorioidal vessels may be injured as little as possible. A firm bandage is applied, and the patient kept in bed for eight or ten days.

The dorsal position in bed, with a pressure bandage on the eye, and diaphoretics internally, the treatment being continued for from four to six weeks, brings about reposition of the detachment in some cases. The method, if properly carried out, is trying to the patient.

The cures which have been accomplished by these means probably depended upon the retina again coming in contact with the chorioid, and, owing to some slight inflammatory process, adhering to it. For the most part the cure is but temporary, and in such cases we may suppose that no adhesion sprang up, but that the temporary cure was due to a return of the sub-retinal fluid, through the hole in the retina, to its original position between the retina and vitreous. Soon, however, it makes its way back again through the opening, and the detachment recurs.

To promote adhesion between retina and chorioid, Dor touches the sclerotic corresponding to the detachment lightly with a small cautery, injects rather strong (10%) solutions of common salt under the conjunctiva, and keeps the patient in bed. He reports some cures by this method.

Sub-conjunctival injections of 4 per cent. saline solution, with rest in bed for some weeks is a treatment also in use.

The foregoing are the principal methods of treatment for detachment of the retina, and there are many others. *The Prognosis* of every case of detached retina is bad, spontaneous cure being extremely rare, and the cures by any one or by any combination of methods of treatment being few and far between; and even when the retina returns to its place, there is the danger of a recurrence of the detachment. Moreover, both eyes are often affected, one after the other. It is important therefore to explain the prospects of the treatment to the patient before it is commenced. The most favourable cases are those due to chorioiditis, the most unfavourable those due to posterior staphyloma.

TRAUMATIC AFFECTIONS OF THE RETINA.

In addition to detachment and rupture of the retina, the undermentioned conditions occur as the results of injuries.

* **Traumatic Anæsthesia of the Retina.**—A blow on the eye from a fist, cork from a bottle, etc., is liable to produce considerable amblyopia, with concentric contraction of the field, which may continue for a long time, while the *Ophthalmoscopic Appearances* are normal. Ultimately these cases usually recover, an event which may be decidedly promoted by the use of strychnine hypodermically; but very defective sight sometimes remains permanently.

* **Commotio Retinæ,** or **Traumatic Œdema of the Retina,** is the result of a blow upon the eye. Immediately after the blow there is marked episcleral injection, and the pupil can be dilated but slowly with atropine. Within a few hours after the accident the *Ophthalmoscope* reveals a white cloudiness (œdema) of a portion of the retina, usually in the neighbourhood of the optic papilla and macula, but sometimes more eccentrically; and sometimes there are two opaque patches. The opacity increases in intensity, and

spreads somewhat. The retinal vessels remain normal; there may be some small hæmorrhages, and sometimes the papilla is redder than normal. These appearances completely disappear in the course of a few days. Vision is only slightly affected, and recovers according as the retinal changes pass off.

* **'Holes' at the Macula Lutea.** (Retinitis atrophicans centralis, of Kuhnt).—Concussion injuries of the eye sometimes give rise to a remarkable lesion at the macula lutea, the precise nature of which is not yet understood. The ophthalmoscopic appearances suggest a punched-out hole, generally of a circular or oval shape. This area is depressed below the level of the surrounding retina, its floor is of a deep red colour, and its margin is sharply defined. In some cases there is a shallow detachment of the retina, but in the majority there is none. Contrary to what would be expected, the functions of the macula lutea, although diminished, are not completely lost, and an absolute central scotoma is not in every case present. Consequently, it must be concluded that, notwithstanding the apparent serious damage, the delicate tissues at the macula lutea, and the nerve-fibres connecting it with the optic nerve are not completely destroyed.

Very similar appearances are sometimes seen, without any history of trauma, following an iritis or irido-cyclitis, or in the eyes of elderly people the subjects of arterio-sclerosis.

CHAPTER XVII.

DISEASES OF THE OPTIC NERVE.

Optic Neuritis.—*The Ophthalmoscopic Appearances* of inflammation of the optic nerve vary a good deal with the intensity of the process. Common to every case is hyperæmia and swelling of the papilla, with haziness (so-called "woolliness") of its margins, and increase in the size of the central vein, while the central artery remains of normal dimensions, or is contracted. The swelling and haziness extend but a short distance into the surrounding retina, and the distension of the vein is also not continued to the periphery of the fundus. In slight cases, these appearances may barely exceed the normal.

In extreme instances, the papilla is swollen to a great size, and may even assume quite a dome shape, while the veins are enormously distended and tortuous, and the arteries are contracted so as to be barely visible. Greyish striæ extend from the papilla into the surrounding retina, some flame-shaped hæmorrhages are present on or near the papilla, and, occasionally, white spots in the retina, and a stellate arrangement of small white dots about the macula lutea, produce an appearance which cannot be distinguished from albuminuric retinitis. This extreme form is still termed Congestion Papilla, or Choked Disc (*Stauungspapille*), although the theory which originally suggested the term has been abandoned, and papillitis (Inflammation of the Optic Papilla) is a better term, expressing, as it does, more truly the pathological condition.

The Vision, even in cases where the ophthalmoscopic signs are highly developed, is frequently but little below the normal; while, again, in other, and possibly less well-marked cases, in so far as the appearances are concerned, it may be reduced to perception of light, or even that may be wanting. When due to cerebral tumour, the neuritis appears, as a rule, before the vision becomes affected. These remarkable differences in the degree of blindness depend, probably, on the extent to which the nervous elements of the inflamed part are pressed on or altered, and this cannot be gauged by the ophthalmoscopic appearances.

Sometimes the field of vision is normal, while again it is concentrically or irregularly contracted, or it may be hemianopic.

An attack of temporary loss of sight is a very common symptom in cerebral tumours; it may occur several times a day, and may last from a few minutes to half an hour.

Pathologically, the changes in the papilla consist in venous hyperæmia, œdema, hypertrophy of the nerve fibres, infiltration of lymph cells, and development of connective tissue. Inflammatory changes, although less pronounced, are also present in the trunk of the nerve and its sheaths.

Causes.—Inflammation of the optic nerve is most commonly found in connection with coarse encephalic disease. A Cerebral Tumour (including syphiloma, tubercle, and abscess) in particular is the most common cause, and is, moreover, usually present when the papillitis is of an intense kind (choked disc). Even a small tumour situated anywhere in the brain is capable of producing optic neuritis, although unattended by meningitis. The most intense neuritis is often that attending a cerebellar tumour. The neuritis, except in very rare instances, is bilateral, and it is one of the general symptoms of cerebral tumour. Hemianopsia may co-exist as a localising symptom, if the visual centre or fibres on one side be involved. Cerebral cysts do not often cause it.

Tubercular Meningitis is the next most common cause. Non-tubercular meningitis occasionally gives rise to optic neuritis, and sometimes, also, cerebro-spinal meningitis does so.

The Connection between Optic Neuritis and Intracranial Diseases has given rise to much discussion, and many divergent views are still held on the subject. In cases of tumour, as well as of tubercular meningitis, a considerable exudation of fluid usually takes place into the cavity of the third ventricle. This, along with the new growth, or alone in cases of meningitis, increases the pressure within the cranial cavity. By reason of this increased intracranial pressure, the subarachnoid fluid is believed to be driven into the subvaginal lymph space of the optic nerve, and to produce there that dropsy of the sheath which is found in many of these cases, on careful post-mortem examination.

Leber holds that this fluid probably contains a phlogogenic substance. It seems probable that the reason why some small cerebral tumours may cause optic neuritis, while some large ones do not, is to be sought in the fact that the former may happen to be rapidly growing tumours, and accompanied by much ventricular dropsy, while the larger tumours may be slow in growth, and may be attended by but little dropsy of the ventricles. Moreover, the fluid driven into the subvaginal sheath of the optic nerve may not be equally rich in phlogogenic substance in the case of every tumour.

The inflammation, although most intense at the papilla, near which the fluid is collected in greatest quantity in the *cul-de-sac* formed by the termination of the intervaginal spaces, is not confined to that place, as was believed, but extends up the trunk of the nerve, as microscopic examination reveals.

Many observers state that, in a large number of cases, cerebritis, recognisable only with the microscope, is present, and that it is an extension of this process down the optic nerve which takes place and causes the papillitis. They have ascertained that the whole trunk of the nerve is involved in the inflammation, and they seem to regard the dropsy of the sheath as of little or no importance in the causation of the optic neuritis.

Again, others maintain that œdema, but not inflammation, of the optic trunk is transmitted from the brain, in consequence of high intracranial pressure, and gives rise to incarceration at the lamina cribrosa and sclerotic ring, and consequent swelling of the papilla.

Other causes for Optic Neuritis are :—

Hydrocephalus.—Here the pathogenesis is probably the same as in the foregoing; but the occurrence of optic neuritis is, on the whole, not very common in this connection.

Tumours of the Orbit.—How these growths bring about papillitis is still unknown.

Inflammatory Processes in the Orbit, such as caries, inflammation of the retro-orbital areolar tissue, erysipelas of the head and face extending to the orbital tissues, and periostitis. The presence of the latter may often be recognised by pain on motion of the eyeball, pain in the eye and forehead, and especially by pain on pressure of the globe backwards, and is frequently of rheumatic origin. Often in these cases one eye only is affected; and, although the *Ophthalmoscopic Appearances* are sometimes very slight, yet vision may be quite lost in a few hours or days, atrophy of the nerve then rapidly setting in.

Very many of the cases, however, do not go on to atrophy, but end in recovery of useful vision.

Exposure to Cold, especially if the skin be heated and perspiring.

Suppression of the Menstruation.—If during the menstrual period the flow be arrested by exposure to cold, wet feet, etc., acute optic neuritis with rapid blindness may come on. Spontaneous amenorrhœa, or even irregularity of menstruation, and the climacteric period are liable to have a similar but more chronic result. Nothing is known with regard to the connection between the uterine and ocular disorder. In these cases the Ophthalmoscopic Appearances, as well as the blindness, are apt to be extreme. Treatment here should be directed chiefly to restoring, when possible, the normal uterine functions. Hot foot-baths and Heurteloup's leech to the temples are of use.

Chlorosis.—Here optic neuritis often is present, due to the disordered state of the blood, and usually yields under the influence of iron.

Syphilis.—The trunk of one or both optic nerves may be the seat of specific inflammation in connection either with congenital or with acquired syphilis, but this primary specific optic neuritis is a relatively rare disease. In cases of acquired syphilis it makes its appearance in from six months to two years after the inoculation.

The Ophthalmoscopic Appearances may be normal (retrobulbar neuritis), or may present any grade of neuritis, even to the most pronounced papillitis. In the latter case it would not be possible to say whether the papillitis is a primary one, or is due to a syphilitic gumma within the cranium. The inflammation often extends as far up as the chiasma.

The Treatment in these cases of specific papillitis must be active mercurialisation. By this treatment, even if perception of light be lost for a period of not more than eight to fourteen days, hopes may be entertained of its complete or partial recovery.

Cases of double optic neuritis of syphilitic origin have been observed, in which complete recovery took place, the papilla returning to its normal condition. But, as a rule, some optic atrophy, at the least, with slight concentric contraction of the field, results. The prognosis is all the better the sooner the optic neuritis follows upon the primary syphilitic affection.

Rheumatism.—There is no doubt whatever but that the rheumatic diathesis is occasionally the cause of optic neuritis, although the fact is not unreservedly accepted by every author. Other manifestations of rheumatism are sometimes well marked, but may be very slight. One or both optic nerves may be attacked.

The Ophthalmoscopic Appearances often amount to extreme papillitis, but in many cases fall short of this.

If the case come early under suitable treatment the Prognosis is fairly favourable; but when the inflammation is of some standing, consecutive optic atrophy must be feared.

The Treatment consists of full doses of salicin, salicylate of sodium, iodide of potassium or of sodium, Turkish baths, and other recognised anti-rheumatic measures.

Lead-Poisoning.—In some cases of lead poisoning optic neuritis, not to be distinguished from that of primary cerebral affections, is found. Sometimes the Ophthalmoscopic Appearances are very slight, and, again, quite pronounced, the changes extending into the retina. They sometimes simulate the retinitis of Bright's disease; and in such cases renal disease is likely to have much to do with the causation of the retinitis. Indeed, there are those who, with good opportunities for forming a correct opinion, deny the existence of a specific lead neuritis, and hold that the neuritic affection in all such cases is to be referred to albuminuria, to effusion into the ventricles of the brain and subarachnoid space, or to accompanying suppression of menstruation. Occasionally optic atrophy is the first ophthalmoscopic appearance seen; but it is probably consecutive to retro-bulbar neuritis, as shown by white striæ (perivascularitis) along the vessels.

The Vision is often much affected, and it is stated that sudden complete blindness in connection with an intercurrent attack of lead colic may appear and pass off again. Consecutive atrophy is liable to come on, and then vision may be seriously and permanently damaged.

The Diagnosis depends entirely on the presence of the other well-known symptoms of lead-poisoning, the Ophthalmoscopic Appearances presenting nothing pathognomonic.

The Treatment is that for general lead-poisoning, or for the immediate cause of the neuritis.

In Peripheral Neuritis optic neuritis is occasionally found.

Multiple Sclerosis.—In these cases the inflammation is very ephemeral, and rapidly gives place to atrophy. Uhthoff states that it occurs in about 13 per cent. of the cases of this disease.

Tabes Dorsalis.—A few cases of this disease are published in which optic neuritis was present. It is probable that the latter depended on co-existent syphilitic cerebral disease, rather than on the spinal disorder as such. In Acute Myelitis inflammation of the optic nerve is sometimes seen, so that optic neuritis with paralytic phenomena does not exclusively indicate cerebral disease.

Hereditary and Congenital Predisposition.—The disease known as Hereditary Optic Neuritis, as Hereditary Optic Atrophy, and as Leber's Disease, commences with sudden and marked loss of sight, the vision falling perhaps to finger counting at 1 to 4 m. Both eyes are always attacked, with an interval of from a few days to two years. The fundus is at first normal, or slight optic neuritis is present. After a few weeks the papilla becomes pale, especially in its temporal half, and gradually the typical appearance of optic atrophy is developed. Examination of the field of vision shows the presence of a relative or of an absolute central scotoma. The periphery of the field is normal, or but slightly contracted.

The disease develops as a rule a few years after puberty —about the twentieth year. The course and conclusion of the disease is not the same in every instance. Most commonly the acuteness of vision and the central scotoma remain stationary, but in some cases improvement, although not complete recovery of sight, has been noted, while in others complete blindness came on. In the same family the course of blindness is apt to be the same. The grosser derangements of the nervous system, such as epilepsy, mental derangements, etc., do not commonly accompany this eye-disease, but the lighter forms, as migraine, vertigo, palpitation of the heart, are often observed. The hereditary transmission usually occurs through the female members of the family to their male children, the females themselves being rarely affected, while several or all of the sons may be attacked.

Treatment is, practically, of no avail. Mercury, iodide of potash, strychnine, and galvanism of the sympathetic have been employed.

Optic Neuritis also occurs occasionally in fevers; it has been observed in Measles, Scarlatina, Typhoid, and Malaria. It may follow Influenza, causing contraction of the field of vision or central scotoma which usually disappear, but, on the other hand, it may lead to optic atrophy.

*__Retro-Ocular Neuritis.__—This is not a very common disease. It is ushered in by rapid, although never sudden, loss of sight in one eye, sometimes in both, or they may be attacked with a considerable interval between. Examination of the field of vision discovers a central scotoma, which is often absolute, and there is impaired pupil reaction to light. The patient sees less well in a very bright light. At the commencement, pain in the orbit is complained of, the motions of the eye are somewhat painful, and there is pain on moderate pressure of the globe backwards into the orbit. Often at first there are no ophthalmoscopic changes, but after a time marked optic neuritis shows itself, and this may pass into atrophy, or atrophy may appear without any previous neuritis which can be discerned. It is rare for complete and absolute amaurosis to result, although the optic disc remains white. In most instances the central scotoma disappears, and almost normal vision is soon again restored; but in some a more or less well-marked central scotoma, with defective sight, remains. The prognosis is all the better if the case come under treatment very early.

Exposure to severe blasts of cold wind on the head, rheumatism, and influenza are the most common causes.

Treatment.—Iodide of potassium in large doses, mercury, and salicylate of soda.

Toxic Amblyopia, or Central Scotoma.—

Symptoms.—The defect of vision often comes on rather rapidly. The patient may complain of a glimmering mist which covers all objects, especially in a bright light, and the acuteness of vision is reduced. The patient generally states he can see better in the dusk than in bright light. At the commencement there is no defect in the field of vision, but simply a general dimness of vision. At a somewhat later stage, examination of the field discovers no defect for a white object: yet, if a small pale green object be employed, it will generally be ascertained that, at a region close to the point of fixation, the colour is not recognised, but seems grey or white; pink may seem blue, and red may appear brown or black; while in other parts of the field the colours are recognised up to their normal boundaries. This is a central colour-scotoma. As the disease advances a white object will be but indistinctly seen in the scotoma; and in some rare cases all power of perception within its area may be lost, even the flame of a candle not being recognised. The scotoma is usually oval in shape, its long axis horizontal, and extends from the fixation point towards the blind-spot of Mariotte (paracentric scotoma); but occasionally it is of much larger dimensions, and sometimes surrounds the fixation point (pericentric scotoma).

Even when the scotoma is very pronounced it remains negative—*i.e.*, it is not observed by the patient as a dark spot in the field, as is a scotoma due to disease in the outer retinal layers. The affection is almost always binocular, and as a rule there is but little difference between the vision of the two eyes.

The Progress of the disease is slow, occupying weeks or months. Restoration of normal vision usually takes place if the defect of vision, although of extreme degree, be not of old standing. In the latter case, while recovery of central vision cannot be expected, the functions in the periphery of the field are usually maintained; and, consequently, these people, although incapacitated from reading, writing, and other fine work, do not lose their power of guiding themselves.

Causes.—With but few exceptions the subjects of this disease are men, and the most common cause is excess in the use of alcohol, or of tobacco, or of both. The kind of alcoholic indulgence most likely to develop the disease is the frequent drinking of small doses of the stimulant. The individual who often gets thoroughly intoxicated, and between times drinks but little, is less liable to contract central amblyopia than he who, although never incapable of transacting his business, takes many half-glasses of whisky or brandy during the day. Dyspepsia and loss of appetite are constantly present in these cases. Other signs of chronic alcoholism need not be present, but one often sees trembling of the hand and head, sleeplessness, and even delirium tremens. The kind of tobacco most likely, when used in excess, to give rise to central amblyopia is shag or twist. Other kinds of pipe-tobacco and cigars may cause it, but we have not known of a case due to cigarette-smoking.

Excess in alcohol is usually combined with excessive smoking, but cases of pure alcohol-amblyopia certainly do occur—although some English authors deny it—as well as pure tobacco-amblyopia. The most common age for tobacco-amblyopia is from thirty-five to fifty—a time of life when men do well to give up, or to very much reduce, their use of tobacco, as well as of alcohol.

Central amblyopia has also been observed in diabetes, in poisoning from bisulphide of carbon, so largely used in the manufacture of indiarubber, from dinitro-benzol, used for explosives, and in poisoning with iodoform, stramonium, cannabis indica, opium, arsenic, and lead.

The Ophthalmoscopic Appearances in the beginning are either quite normal, or there is slight hyperæmia of the papilla and retinal vessels; or, in addition, there may be slight indistinctness of the margins of the papilla, and sometimes white striæ along the vessels, especially before they leave the papilla. All the primary appearances, if any be present, soon pass away, and give place to a greyish whiteness of the temporal side of the papilla, while the nasal portion remains of normal appearance, as do also the vessels. At a very advanced stage, in some cases, the whole papilla presents the appearance of white atrophy.

The Pathological Changes, in the optic nerve, consist of an interstitial neuritis at its axis, commencing so high up as the optic foramen, and leading to proliferation of connective tissue and to secondary descending atrophy of a certain bundle of nerve fibres. These are the fibres which supply the region of the macula lutea. The changes are analogous to those which take place in the liver and brain as the result of chronic alcoholism.

Treatment consists, above all, in total abstinence from the poison in question. The patients are generally ready to promise this, but they often do not act up to their intentions. When they do so, improvement rapidly takes place in most cases which are not too far gone, without any other treatment; but the cure may be promoted by the use of iodide of potassium in large doses, Heurteloup's artificial leech or dry cupping to the temples, hot foot-baths, and Turkish baths. Strychnine hypodermically ($\frac{1}{30}$ grain daily) in the temple is often of use, and phosphorus and strychnine may be given internally. Whatever remedy be used internally, care should be taken that it does not produce or increase dyspepsia; and it may be necessary to restrict the internal medicine for a time, or altogether, to a stomachic tonic, with abundant drinking of hot water. Sleeplessness should be combated with sulphonal, or bromide of potassium. Treatment may have to be continued for some weeks, before a cure can be noted.

Atrophy of the Optic Nerve.—This disease may be secondary to some other optic nerve or retinal affection, or it may be a primary disease. *The Vision* is seriously affected, and complete blindness is the usual result. With the *Ophthalmoscope* the optic papilla is seen to have lost its delicate pink colour, and to have become white or greyish, while it is often cupped, and the vessels are apt to be diminished in calibre.

Secondary Atrophy of the Optic Nerve may result:—

1. *From Optic Neuritis.*—The ophthalmoscopic appearances consist in a white or greyish-white colour of the papilla, with very diminished retinal vessels; and along both sides of the vessels, far into the retina, are seen white lines, which sometimes even obscure the vessels, and which are due to hypertrophy of their coats. The diminution in calibre of the vessel is a sign of neuritic atrophy, but is not always present, and is moreover found with other forms of atrophy. Other signs of this form, also not constant, are: a certain opacity of the papilla, and that the lamina cribrosa is not generally visible, owing to development of connective tissue at the papilla. It is evidently not always possible to recognise any given case as of neuritic origin.

Symptoms.—The acuteness of vision is lowered, and as a rule the field of vision becomes contracted, usually more at the nasal than at the temporal side. Subsequently the temporal side of the field becomes contracted, and finally a small eccentric portion of the field to the temporal side may be all that remains, or even this may disappear, and absolute amaurosis result. The colour-vision is always much affected. The light-sense is affected, so that there is diminished sensibility for differences of illumination; while, in chorioido-retinal diseases, there is defect in the quantitative perception of light, the minimum quantity being larger than normal.

2. *From Pressure.*—This may be brought about by a tumour anywhere in the course of the nerve, by inflammatory exudations, by a splinter of bone in cases of fracture of the skull, and, also, by pressure upon the chiasma by the floor of the distended third ventricle in cases of internal hydrocephalus.

3. *From Embolism of the Central Artery of the Retina.*—In these cases the contraction of the vessels is usually extreme.

4. *From Syphilitic Retinitis, Retinitis Pigmentosa, and Chorioido-retinitis.*—The vessels here are much attenuated, and the altered colour of the optic disc is a dull yellow, rather than white or grey.

5. *Hereditary Optic Atrophy. Leber's Disease.*—(See p. 546.)

Primary Optic Atrophy is often found associated with:—

Disease of the Spinal Cord (*Spinal Amaurosis*), especially locomotor ataxy. Optic atrophy is often an early symptom in the latter disease; but, again, it may not come on until the affection of the gait is well pronounced, while in other cases it is never present at all. It is a remarkable and important fact, first pointed out by Benedikt of Vienna, that there is an antagonism between atrophy of the optic disc and the other symptoms of tabes dorsalis. It is rare for a tabetic patient, in whom optic atrophy comes on in an early stage of his disease, to become ataxic; and frequently, in these cases, when the blindness has advanced, the pains, too, become less severe. But if amaurosis does not come on until the ataxy is well developed, no improvement in the latter is likely to be noted.

More rarely, atrophy is found with insular sclerosis, and lateral sclerosis of the spinal cord; and, in general paralysis of the insane, although spinal disease is not always present, atrophy of the papilla frequently occurs.

It is probable that the disease commences at the papilla in spinal cases. The ophthalmoscope displays a papery-white or bluish-white papilla, which in advanced stages often becomes cupped. The retinal arteries are usually extremely reduced in calibre, and the veins, too, may be small; but, again, the retinal vessels may differ but little, or not at all, from the normal.

Symptoms.—Central vision is affected at an early stage in the disease, and eccentric contraction of the field usually appears at the same time. The contraction may be concentric, or it may be more marked in one direction than another, and opinion is divided as to the direction commonly first involved. This concentric contraction advances gradually towards the centre of the field from every side, until it finally engulfs the fixation point.

Occasionally the affection begins as a central scotoma, accompanied by eccentric defects of the field. Colour-blindness is an almost constant symptom. As a rule absolute blindness is brought about in the course of a year or two.

Primary Optic Atrophy of the progressive form just described may occur *As a Purely Local Disease*, without any other defect in the system. The prognosis for the sight in such cases is as serious as in spinal cases.

Treatment.—In neuritic atrophy, so long as there are signs of active inflammation, antiphlogistic measures—Heurteloup's leech to the temple, hot foot-baths, rest of body and mind, dark room, iodide of potassium, and, especially, mercury internally, when otherwise admissible—are to be adopted. At a later period, hypodermic injections of strychnia ($\frac{1}{30}$ gr., increased gradually to $\frac{1}{20}$ or $\frac{1}{18}$ gr. once a day) and galvanism may be tried. Hypodermic injections of antipyrin (about

$7\frac{1}{2}$ grains every second day) have been given with some benefit in these cases.

In spinal amaurosis, and in optic atrophy occurring as a local disease, strychnia hypodermically and the galvanic current sometimes improve vision for a time. Phosphorus internally may be given.

The treatment for optic atrophy, due to causes 2, 3, and 4, is to be directed to the primary disease.

The Prognosis is very serious; for, although every therapeutic measure may have been employed, amaurosis is the ultimate result as a rule.

Tumours of the Optic Nerve will be treated of in chap. XIX.

* **Hyaline Outgrowths** from the optic papilla, at its edge or centre, are occasionally met with. Seen with the ophthalmoscope, they present tho appearance of small bluish-grey semi-translucent nodules. In many instances retinitis pigmentosa is also present. These outgrowths do not of themselves always cause a defect of sight, and rarely cause serious blindness.

Treatment is of no avail.

* **Injuries of the Optic Nerve.**—In addition to those injuries which result from direct violence with sharp instruments, etc., entering the orbit, the optic nerve may be injured by falls on the head. Fractures of the base of the skull frequently involve injury to the optic nerve. But even where no fracture occurs, blindness with atrophy of the optic nerve may come on, usually only in one eye; and in these cases concussion of the nerve at its passage through the optic foramen, or an extravasation of blood in the sheath of the nerve, is probably the immediate cause of the atrophy.

* **Hæmorrhages from the Stomach, Bowels, or Uterus** are capable of giving rise to serious and incurable blindness.

Blindness during or immediately after a severe hæmorrhage is probably due to insufficient blood-supply to the nerve-centres and retina, accompanying general exhaustion of the system. For such cases the prognosis is favourable.

But there is another class of cases of very much more serious import. In these the defect of vision does not come on until from two to fourteen days after the hæmorrhage, when the general system is recovering. Even comparatively slight hæmorrhages, which caused no marked anæmia, are said to have been followed by blindness. The connection between the loss of blood and of sight in these cases is not yet clearly made out. Leber inclines to the belief that, the blindness here is due to an extravasation of blood at the base of the skull, and into the sheath of the optic nerve; but, even then, the relationship between this and the stomachic or uterine hæmorrhage is not made clearer. Papillitis has been several times noted with the ophthalmoscope in these cases; and this circumstance makes it probable that neuritis is the immediate cause of blindness—even in those cases which show no ophthalmoscopic sign of it—and hydræmia may be presumed to be the influence which calls forth the neuritis.

The Defect of Vision may be but slight, or it may amount to absolute amaurosis. Both eyes are usually affected in equal degree. But cases have been observed in which one eye was completely amaurotic, while the vision of the other eye was quite normal; and one such case is sufficient to prove that the lesion is peripheral—in fact, that it lies in each instance on the distal side of the optic chiasma. The field of vision is frequently contracted, either concentrically or segmentally; and, even when central vision recovers, the field may remain contracted.

The Ophthalmoscopic Appearances which are present immediately on the occurrence of the blindness have not as yet been observed. A few weeks later they have been found to be different in different cases. They have been found at this period normal; or presenting slight paleness of the papilla and contraction of the arteries; or there was marked paleness of the papilla, and the arteries were extremely contracted, with slight distension of the veins; or paleness of the papilla was present, but its margins were indistinct, and the surrounding retina somewhat swollen, while the retinal vessels were normal. Small hæmorrhages have repeatedly been seen in the neighbourhood of the papilla. At later periods well-marked optic atrophy is frequently observed.

Prognosis.—If in the beginning the defect of vision be merely amblyopia, and not complete blindness, hopes may be entertained of marked improvement, or of complete recovery. But Mooren saw slight amblyopia pass into permanent amaurosis.

Hæmorrhages from the stomach are those which are followed by the most complete and permanent blindness, while uterine hæmorrhages are more commonly followed by less serious degrees of blindness.

The Treatment must consist of internal remedies calculated to correct the general anæmia, such as iron, beef-tea, and meat extracts, wine, etc. Strychnine hypodermically, to stimulate the nerve, may be employed.

Glycosuric Amblyopia.—In addition to the retinal affections dependent upon diabetes, we recognise the occasional occurrence in that disease of defects of vision which are referred to disorder of the optic nerve, and which are not always accompanied by ophthalmoscopic changes. These defects of vision are found in the form of (1) Central Amblyopia (see p. 548), or, in slighter cases, as amblyopia without central scotoma. Occasionally, higher degrees of amblyopia with concentric contraction of the field of vision, and yet negative ophthalmoscopic appearances, are present. (2) Atrophy of the optic nerve. This may appear in the usual form as progressive blindness, with concentric contraction of the field of vision; or it may come on after the slighter form of amblyopia has existed for some time. (3) Hemianopsia and colour-blindness.

It is probable that these apparently different kinds of blindness depend upon similar pathological processes, and merely indicate degrees of the latter. In what these processes consist is still unknown; but the tendency to hæmorrhages in the retina in diabetes makes it likely, that hæmorrhages in the optic nerve are sometimes the source of the amblyopia in question; while, in the cases with central scotoma, it is no doubt due to retro-bulbar neuritis, similar to that produced by tobacco, etc.

Amblyopia is sometimes the only symptom of diabetes; and, consequently, it is of the utmost importance to examine the urine for sugar in every case of amblyopia where the ophthalmoscopic appearances are negative, or where the only abnormality is atrophy of the optic papilla.

The Treatment indicated is solely that for the general disease, and the prognosis for vision depends upon the amenability of the latter to treatment, and upon the extent to which organic changes in the optic nerve have proceeded.

CHAPTER XVIII.

THE ORBITAL MUSCLES AND THEIR DERANGEMENTS.

NORMAL ACTION OF THE ORBITAL MUSCLES.

THE eyeball, which is held in position by the orbital fascia and capsule of Tenon with its orbital prolongations, moves round a point on its antero-posterior axis, situated (in the emmetropic eye) 14 mm. behind the cornea, and 10 mm. in front of the posterior surface of the sclerotic. Its motions are effected by means of the six orbital muscles, arranged in three pairs, each pair consisting of two antagonistic muscles; thus the rectus internus and rectus externus are antagonistic, the former rotating the eye inwards, and the latter rotating it outwards. The remaining pairs are the recti superior and inferior, and the obliqui superior and inferior.

The Primary Position of the Eyeball is that one in which, the head being held erect, the gaze is directed straight forwards in the horizontal plane. This is the starting-point from which the actions of the muscles are considered.

The Rectus Externus and Rectus Internus, lying from their origin to their insertion in a plane which corresponds with that of the horizontal plane of the eyeball, move the latter on its perpendicular axis directly inwards and outwards, and have no other action.

The Superior and Inferior Recti arise at the back of the orbit to the inner side of the eye, and pass forwards and outwards. Therefore the plane of these muscles does not correspond with the vertical plane of the eyeball, but passes from within and behind, forwards and outwards. Consequently their axis of rotation, though lying in the horizontal plane, is not the horizontal axis of the eyeball, but one which, passing from within and before, backwards and outwards, forms with the antero-posterior axis an angle of 70° (Fig. 181). Being inserted *in front* of the centre of rotation, their action is mainly to rotate the eyeball upwards and downwards, but, coming from the inner side, they also rotate it somewhat inwards. Moreover, the superior rectus giving to the vertical meridian of the cornea an inward inclination,[1] or inward wheel-notion of the eye (*vide infra*), while the inferior rectus gives this meridian an outward inclination,[1] or outward wheel-motion of the eye. The power of these muscles over the upward and downward motions is greatest when the eye is turned out, for then their axis of rotation coincides most closely with the horizontal axis of the globe; and their influence over the wheel-motion is greatest when the eye is turned in, for then their axis of rotation coincides most closely with the antero-posterior axis of the globe.

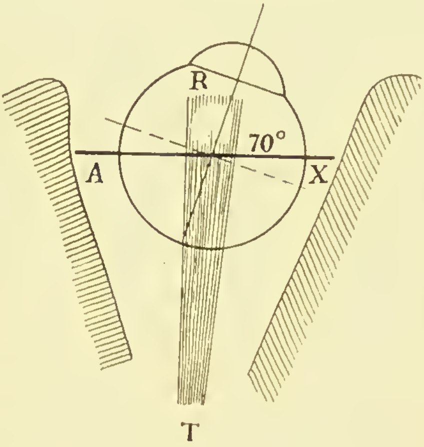

FIG. 181. Left Eye.

The plane of the *Oblique Muscles* of the eyeball also approaches the vertical plane of the eyeball, the axis upon which they rotate the latter passing from within and behind, forwards and outwards, and making with the antero-posterior axis an angle of 35° (Fig. 182). The principal action, accordingly, of the oblique muscles is to incline the vertical meridian of the cornea; the superior oblique inclines it inwards (wheel-motion inwards), the inferior oblique inclines it outwards (wheel-motion outwards). In addition to this, since the fixed point from which they act is at the front of the inner side of the orbit, and since they are inserted *behind* the centre of rotation, they will each of them rotate the eyeball outwards. Moreover, the superior oblique will move the eye downwards, and the inferior oblique will move it upwards. It is evident that the power of the oblique muscles over the upward and downward motions of the eyeball is greatest if the eye be turned in, and that their power over the wheel-motion is greatest when the eye is turned out.

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[1] In speaking of the inclination of the vertical meridian of the cornea it is the upper extremity of this meridian which is meant. Inward means toward the nose or median plane of the head, and outward towards the temple. These wheel-motions are sometimes designated by the terms intorsion and extorsion.

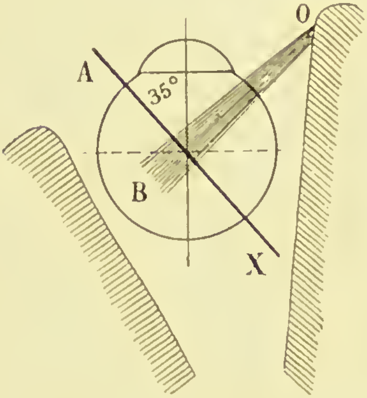

FIG. 182. Left Eye.

To sum up then: *Vertical motion.*—The recti move the eye in the direction indicated by their names, the superior upwards and the inferior downwards. The obliques move the eye in the opposite direction to their names, the superior oblique moving it downwards, and the inferior oblique upwards.

Horizontal motion.—The recti move the eye inwards, the obliques move it outwards.

Wheel-motion (torsion).—The superior (rectus and oblique) muscles rotate the vertical meridian inwards; the inferior (rectus and oblique) muscles rotate the vertical meridian outwards. The action of the obliques on the wheel-motion is greatest when the eye is rotated outwards, and of the recti when the eye is rotated inwards.

1. *In the Primary Position* all the muscles are at rest.

2. Motion of the eyeball *directly outwards* is affected by the external rectus alone, and motion *directly inwards* by the internal rectus alone.

3. Motion of the eyeball *directly upwards* and *directly downwards* is effected chiefly by aid of the superior and inferior recti. But these muscles acting alone rotate the eye slightly inwards, and tilt the vertical meridian, which in this position should be upright. The assistance of the obliques is therefore necessary to counteract these subsidiary effects. For example, the superior rectus moves the eye upwards and inwards, and inclines the vertical meridian inwards; the inferior oblique moves it also upwards, but at the same time turns it outwards, and inclines the vertical meridian outwards, so that when the two muscles act together, the second and third effects mentioned neutralise each other, and the result is a vertical motion upwards. Similarly, the inferior rectus requires the assistance of the superior oblique.

In oblique positions of the eyes, the vertical meridian no longer remains vertical but becomes tilted, as shown in Fig. 183.

4. Rotation *upwards and outwards* is effected by the superior rectus, inferior oblique, and external rectus; but since in an outward position of the eyeball the torsion effect of the obliques is at its greatest, while that of the recti is diminished or *nil*, the action of the inferior oblique in this respect will preponderate, and the vertical meridian will therefore be inclined *outwards*. (2′ or 4, Fig. 183.)

5. Rotation *downwards and outwards* is due to the action of the inferior rectus, superior oblique, and external rectus, and here also the torsion effect of the oblique muscle will prevail,

and the vertical meridian will be inclined *inwards.* (3′ or 5, Fig. 183.)

6. *Upward and inward* rotation is produced by the superior rectus, inferior oblique and internal rectus, but in the inward position of the eyes the torsion effect due to the rectus will prevail over that due to the inferior oblique, and the vertical meridian will thus be inclined *inwards.* (4′ and 2, Fig. 183.)

7. In rotation *downwards and inwards* the inferior rectus, superior oblique, and internal rectus act together; and, for the reason just mentioned, the vertical meridian will be inclined outwards by the inferior rectus. (5′ and 3, Fig. 183.)

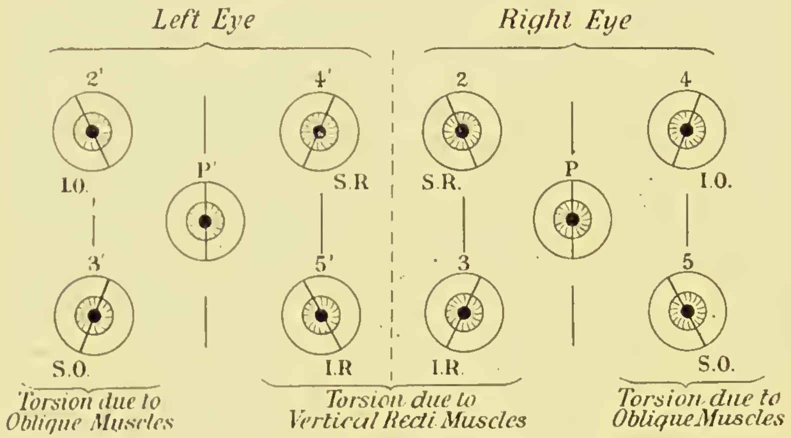
Left Eye
Right Eye
2'
4'
2
4
I.O.
P'
S.R
S.R.
P
I.O.
3'
5'
3
5
S.O.
I.R
I.R.
S.O.
Torsion due to Oblique Muscles
Torsion due to Vertical Recti Muscles
Torsion due to Oblique Muscles

FIG. 183.—Illustrates the torsion of the vertical meridian in oblique positions of the eyes. In motions of both eyes the meridians are inclined in the same manner, as at 2 and 2′, 3 and 3′ and so on. Compare this with Fig. 188.

So far the movements of each eye have been considered as taking place separately, but in reality the eyes move simultaneously, their movements being associated. Parallel movements of the eyes in various directions are called conjugate, while inward rotation of the eyes, for the purpose of fixation of near objects, is known as convergence. Conjugate movements may also take place combined with convergence.

*In conjugate movements of the eyes into oblique positions, even with parallel visual axes, a symmetrical wheel-motion, or torsion, occurs as shown in Fig. 183. In the primary position (P. and P.′), and also when the eyes are turned directly to the right, to the left, upwards, or downwards, the vertical meridians of the corneæ (as indicated by the lines passing through the pupils), maintain their vertical direction. In other positions this meridian becomes tilted to one or other side, but in the same direction for each eye. For example, on looking to the left and upwards the inclination of the vertical meridian is to the left in both eyes (Fig. 183, 2′ and 2.). The effect of motion in the three other oblique positions is also shown. The explanation of this torsion has already been given when the movements of the eyes separately were discussed.[1]

*The muscles which act together in conjugate movements are said to be associated. The right internal rectus, for example, is the associate of the left external rectus, in movements of both eyes to the left. In the vertical movements directly upwards and downwards, the two muscles engaged in one eye are associated with the corresponding two muscles in the other eye; but, in the oblique positions, the muscles which are mainly associated in their action are those of which the names are opposed in every way. For example, in looking to the left and upwards (in addition to the lateral recti) the real associates are the *left superior rectus* and the *right inferior oblique*; because, in this position, the axis of the left eye lies in the plane of the recti muscles, while the axis of the right eye lies in the plane of the oblique muscles.

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[1] This effect is often called "false torsion," because it is not directly due to the twisting of the eye on its antero-posterior axis, but to the fact that the rotation into the oblique position is accomplished by movement of the eye on an oblique axis, which lies in the equatorial plane (Listing's plane) of the eyeball.

***Subjective and Objective Localisation or Orientation.**—An image of the field of vision is formed on the retina, and the image of each object in the field is "projected" outwards along the secondary axis passing through the nodal point, or optical centre, of the eye, to its proper position in the field. This relation of objects to one another in space is called *objective* localisation.

Subjective localisation consists in the appreciation of the position of the body in relation to external objects, and is gained chiefly through the sense of muscular effort necessary to bring the eyes into position for the fixation of those surrounding objects. Hence arises the false judgment of position and the resulting giddiness, caused by sudden disturbance of function of the orbital muscles.

***The Field of Fixation.**—The field of fixation contains all the points which the eye can successively see or "fix" without movement of the head. It can be measured with the perimeter, as in testing the field of vision, except that here the patient is made to move the eye as far as possible in each meridian, and the limit of each movement is measured by observing the corneal reflex of a candle flame, or ophthalmoscope mirror, which is moved along the arc of the perimeter. The *binocular* field of fixation contains all those points which can be seen as single with the two eyes and without movement of the head. According to Landolt, the averages give, for movement of one eye, inwards 44°, outwards 46°, upwards 44°, and downwards 50°.

STRABISMUS.

When looking at any object with the two eyes it is necessary, in order to avoid seeing double, that the visual axis of the eyes should meet at the point fixed. When this does not take place, one of the eyes must be in a faulty position, or, as it is commonly termed, it squints. This condition is called *Strabismus,* and may arise either from over-action or from paralysis of one of the muscles. Strabismus may occur in any direction, but vertical and oblique deviations are less common than the convergent or divergent forms.

In order to ascertain, in slight cases, which is the deviating eye, the patient is made to fix an object, and one eye, say the left, is rapidly covered with the surgeon's hand; then, if the right eye make no movement, it must have been looking at the object before the left one was covered; but if, on covering the right eye, the left make a movement in order to fix the object, then this eye must be the squinting one. The movement is always in the opposite direction to the deviation. For instance, if the eye be turned inwards too much, it must of course turn outwards to fix the object, when its fellow is covered. Another good method consists in observing the position of the corneal reflex when the patient looks at the ophthalmoscope (see Measurement of Strabismus). But the most delicate test is the character of the diplopia, if diplopia be present.

Apparent Strabismus is due to a large angle γ (p. 24). In this case, as the visual axes are both directed to the point fixed, there will be no movement of either eye on covering the other, as in true strabismus.

***Latent Strabismus,** also called **Muscular Insufficiency** or **Heterophoria.**—In these cases strabismus only occurs under exceptional conditions, such as the use of tests which interfere with, or render more difficult, binocular vision. Under the usual conditions, binocular vision is maintained in these cases, but this involves a muscular effort greater than normal, and hence these patients suffer from muscular asthenopia.

Binocular Vision. Sense of Fusion.—When an object is seen by the eyes in direct vision, the visual axes meet at the object or point of fixation (*binocular fixation*), and the retinal images are fused by a cerebral process, so that the object appears single. This constitutes *binocular single vision.* All objects in that portion of the field which is common to both eyes form images on corresponding parts of the retinæ, and they too are perceived as single. The slight differences in the images of an object as seen from the point of view of each eye generates the perception of relief or stereoscopic vision, which is the highest degree of binocular vision. The *fusion sense* or desire for single vision develops in infancy, but in different individuals it may exist in different degrees. Binocular fixation may, for instance, be present without true fusion, only one of the images being perceived, while the other is suppressed ; as is proved by the inability sometimes to produce double vision by means of a prism. Not only this, but the sense of fusion is more easily disturbed in some persons than in others, when binocular vision is rendered difficult by artificial means.

The existence or otherwise of true binocular vision may be ascertained by the simple experiment of giving the patient a book to read, and then holding a cedar pencil halfway between his eyes and the page, at right angles to the lines of type. If binocular vision be present, the pencil will not offer any impediment to the reading ; but, if it be not present, parts of the page will be hidden behind the pencil. The reader may prove this by performing the experiment on himself, first with both eyes open (binocular vision), and then with one eye shut.

Another method is that known as Hering's Drop Experiment. A hollow cylinder about 25 cm. long, and wide enough to take in both eyes of a person, is provided—at the opposite end from that placed around the eyes—with two strong wires 18 inches long, which jut out in continuation, as it were, of the cylinder, but which are bent outwards sufficiently to keep them out of the view of the patient. Between the ends of these wires a fine thread is stretched, with a small bead fastened at its middle point, so that the bead may occupy the centre of the field when the patient looks through the cylinder. During the experiment the thread is in the horizontal position, and the bead is used as the patient's fixation point. Small balls of different sizes (peas, beans, etc.) are then let fall from a height, one after another, a couple of dozen times or more, some of them in front of the thread, some of them behind it. If the patient have normal binocular vision, he will be able to say each time with certainty whether the ball falls in front of, or behind the thread; but if he have not true binocular vision, if only one eye be used, he will merely guess at the position of the falling ball, and will make frequent mistakes.

Binocular Vision can also be tested by the stereoscope in its various forms.

Diplopia, or double vision, always occurs in the absence of binocular fixation—*i.e.*, when strabismus is present—provided binocular vision had previously existed. One image is seen by each eye, and the double vision disappears on closing one eye. This is binocular diplopia, as distinguished from monocular diplopia, in which two images are formed on the retina of one eye, as the result of irregular refraction (incipient cataract, dislocated lens, irregular astigmatism, double pupil).

The image seen by the eye which looks at, or fixes, the object is called the "true image." That which corresponds to the deviated eye is the "false image"; and, as it does not lie on the macula lutea, it appears less distinct than the former. The false image always appears to the patient to be, or is "projected" by him, in the opposite direction to the displacement of the eye, so that the diplopia is the reverse of the position of the eyes.

When the image of the affected eye lies to the corresponding side the diplopia is termed homonymous. *Homonymous double vision* always indicates *convergence* of the visual lines. Fig. 184 explains the occurrence of homonymous diplopia in convergent paralytic strabismus.[1] The right eye fixes the object *o*, and its image falls on the macula lutea *m*; but the left eye, by reason of the paralysis of the external rectus, is turned in, and its visual axis lies in the direction *m v*, and the image of *o* falls to the inner side of the macula lutea at *a*. Now why should this image not be referred to its correct position along the line *a o*? The reason is that the patient is not conscious of the deviation of this eye; and, having always been in the habit of superposing

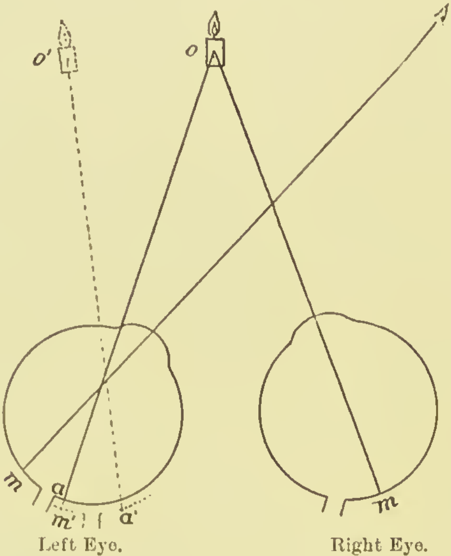

FIG. 184.

his fields of vision, so that the visual axes of the eyes meet at the object fixed, he imagines that this is still the case, and that *v m* lies in the position of *o a*, and that the macula lutea *m* is at *m'*. But if this were so, *a* would be at *a'*, and in this position of the eye, images formed at *a'* to the inner side of the macula lutea are projected to the outer side of the field, along the line *a′ o′*, and the patient imagines that *o* occupies the position *o′*, as seen with the left eye.

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[1] For the sake of simplicity in the diagram the effect which rotation of the eye has on the nodal point is omitted.

If the left eye were deviated outwards, the image of *o* would fall to the outside of the macula, and would therefore be projected to the right of the true position of the object. The right image would then belong to the left eye and *vice versa*; this is *crossed diplopia*, and indicates *divergence* of the visual lines. A very simple experiment will prove this: when a finger is held up in front of the eyes, and a distant object is fixed, it will be noticed that the finger is seen double; if now the right eye be closed, the left image of the finger will be found to vanish. The diplopia here is crossed because the convergence of the eyes is less than that required for fixing the finger—there is, in fact, a relative divergence. If the finger be now fixed, a bright object further away will be seen double, but the diplopia will be homonymous, because the eyes are convergent. This is a physiological diplopia, and as we pay no attention to it from habit, we are not disturbed by its existence.

When an eye is deviated upwards or downwards, the corresponding image is projected downwards or upwards; and torsion of the vertical meridian in one direction produces a tilting of the image in the opposite direction.

It is necessary that the foregoing shall have been clearly understood, before the study of paralysis of the orbital muscles is approached.

PARALYSES OF THE ORBITAL MUSCLES.

Loss of power of one or more of the muscles of the eyeball is, of course, always to be regarded as a symptom, not as in itself a disease.

This loss of power may be due to lesions in several different situations, namely:—(1) Lesions situated in the orbit. (2) Basic lesions—lesions situated at the sphenoidal fissure, and those at the base of the skull, between the sphenoidal fissure and the pons. (3) Pontine lesions, which may be Fascicular—*i.e.*, involving the ocular nerve fibres in the substance of the pons, or Nuclear—*i.e.*, only attacking the nuclei of the nerves in the aqueduct of Sylvius and floor of the fourth ventricle. (4) Cerebral lesions—lesions above the nuclei, in the internal capsule, corona radiata, or cortex. These four classes differ considerably in their clinical aspect, in their pathological causes, and in their significance for the well-being of the patient.

The first class—loss of power due to orbital lesions—will be considered in the chapter on Diseases of the Orbit.

The second class—those due to basic lesions—provides by far the largest number of cases of paralyses of the orbital muscles. Let us now consider the

General Symptoms of this second class. They include symptoms to be found in each of the other classes. (1) Strabismus due to the action of the opponent muscle. (2) Loss or diminution of movement in the direction of normal action of the affected muscles. (3) Diplopia, or indistinct vision, due to the strabismus. If the paralysis be but slight, actual diplopia may not be present, but the double images overlapping each other will cause dimness or confusion of sight. (4) Giddiness and uncertain gait, due partly to the diplopia, and partly to faulty projection of the object. By faulty projection is meant the false idea of the position of the image in the field of fixation. Difficulty in walking and working is most noticeable when a depressor muscle is affected. (5) Some patients turn the head towards the side of the paralysed muscle, in order to diminish or eliminate the diplopia—*e.g.*, if the left ext. rectus were paralysed, the head would be turned towards the left; if it were the left int. rectus, the head would be turned towards the right. By this manœuvre the loss of the action of the affected muscle is less felt for those objects which lie straight in the patient's path, while he walks about; because it involves a rotation of the eye towards the side of the healthy antagonist, in which region of the binocular fixation field the diplopia is reduced to a minimum. Some patients close one eye to procure single vision. In peripheral paralysis it is most common to find only the muscle, or muscles, supplied by some one nerve—the third, fourth, or sixth—affected; although, of course, exceptions to this are not rare, especially where a neoplasm forms at the base of the skull.

In studying a case of paralysis of an orbital muscle the following *General Principles* should be borne in mind:—(1) The defective mobility and the diplopia increase towards the side of the affected muscle—towards the left, if the left external rectus be paralysed; towards the right, if the left internal rectus be paralysed. The image which is furthest in the direction in which the diplopia increases belongs to the paralysed eye. (2) The secondary deviation (*i.e.*, the deviation of the sound eye while the affected eye fixes) is greater than the primary deviation (*i.e.*, the deviation of the affected eye while the sound eye fixes); because the muscle in the sound eye, which is associated in its action with the paralysed muscle in the affected eye (*e.g.*, the rect. int. with the rect. ext.), must receive a nervous impulse of equal intensity to that sent to the weak muscle, and, as the latter requires a considerable impulse to excite its action, its associate will be over-excited. Let us suppose the left external rectus to be paralysed, and that, shading the right eye with a hand, we direct the patient to fix with his left eye an object held somewhat to his left side; we may notice, on removing the shading hand, that the right eye has been rotated inwards to an extent far exceeding that of the primary deviation of the left eye, and has now to make an outward motion in order again to fix the object. (3) The image formed on the retina of the affected eye is projected (*i.e.*, seems to the patient to lie) in the direction of the paralysed muscle; in other words the position of the false image corresponds to the normal action of the paralysed muscle, because the deviation of the eye is in the opposite direction to the action of the paralysed muscle—*e.g.*, if the left ext. rect. be paralysed, the image corresponding to that eye will be projected to the left of the image belonging to the right eye. (See Diplopia p. 567.) When the affected eye fixes alone, the faulty projection is twice as great as when fixation is binocular. (See General Principle, No. 2.)

The deviation of the eye, or strabismus, alone is in the opposite direction to the paralysed muscle; all the other signs, defective mobility, false projection, increase of diplopia, secondary deviation, and position of the head, are towards the paralysed muscle. The special symptoms due to paralysis of individual muscles will now be considered.

Paralysis of the External Rectus of the Left Eye.—If this be complete or considerable, it is easy of diagnosis, as marked loss of power and motion of the left eyeball outwards is present, and the patient complains of double vision. He keeps his head turned to the left, in order to diminish the influence of the paralysed muscle as much as possible.

If, however, the paralysis be but slight, the patient may not complain decidedly of diplopia, but only of indistinctness or confusion of sight, especially when he looks towards the left. To decide the diagnosis in such a case, the double images must be examined. A long lighted candle is used as the object to be looked at; and one eye—let us say here the left eye—is covered with a bit of red-stained glass in order to differentiate the images.[1] The candle is now held on a level with the patient's eyes, and straight opposite him, at about three metres' distance (eyes in primary position). (*a*) In this position the images are seen very close together or overlapping each other, both of them upright and on the same level, the red candle to the left, the white to the right—*i.e.*, homonymous diplopia = convergence. This convergence must be due to paralysis of one or other external rectus muscle, but we cannot say at this stage of the experiment which of them is affected. (*b*) In order to determine this point the candle must be carried from side to side, and the increasing or decreasing distance of the images from each other noted. If the candle be carried slowly to the right, the patient following it with his eyes without turning his head, the images come still closer together, or only one candle is seen. But if the candle be carried to the patient's left-hand side, the images go farther apart, their relative positions being maintained. We now know that it is the left external rectus which is affected: because towards the left—the direction in which the action of this muscle is most wanted, and consequently its loss most felt—the distance between the double images increases. The images are erect, as no wheel-motion is caused by action of the external rectus. (*c*) If, however, the candle be held to the left and raised aloft, the image belonging to the left eye will seem to lean away from, and to be a little lower than, that of the right eye (Fig. 185). The reason of this is that, owing to the paralysis of the external rectus, the left eye cannot look sufficiently outwards, but merely looks upwards. The inferior oblique loses some of its torsional power, but retains a greater power of elevation. The left eye therefore is higher than the right, and its vertical meridian remains vertical. But the right eye, which is free to follow the candle, looks up and to the left. Its vertical meridian is therefore inclined to the left. That is, the vertical meridians of the two eyes converge at the top, which necessitates a divergence of the upper extremities of the images. The rotation of the right eye

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[1] Maddox's Rod Test, described further on, is very suitable here, and in the investigation of other forms of ocular palsy.

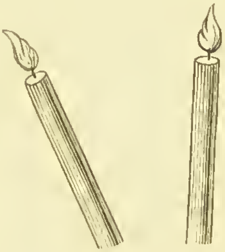

FIG. 185.

in this position is physiological, and its image is therefore judged to be vertical; while the image of the left eye diverging from that of the right, though really vertical, is judged to be oblique. An analogous displacement of the eye downwards, and defective rotation of the vertical meridian due to the superior oblique, takes place in the position below and to the outside. (*d*) If the patient be told to direct his gaze specially towards the red candle—*i.e.*, the image which belongs to the left, the affected, eye—the distance between the two candles will be much greater, than if he direct his gaze towards the white candle. This is explained by General Principle No. 2 (p. 571).

If the patient's good eye be closed, and an object (surgeon's finger) be held up within his reach, but towards his left side, and he be requested to aim rapidly at it with his forefinger, he will aim to the left of it. The nervous impulse sent to his left external rectus, to enable him to turn the eye towards the object, is of such intensity as to lead him to fancy that the object lies much farther to the left than is the case (incorrect projection of the field of view); for we, to a great extent, estimate the distance of objects from each other by the amount of nervous impulse supplied to our orbital muscles in motions of the eyeball.

A prism held horizontally before the affected eye with its base outwards brings the double images closer together; or, if the correct prism be selected, the images will be blended into one.

***Paralysis of the Superior Oblique of the Left Eye.**—This paralysis will be most apparent when a demand is made for motion of the eyeball downwards and inwards, the action of the superior oblique as a depressor being greatest in this position. Yet absolute defect of motion is sometimes difficult to detect, even in complete paralysis of this muscle, owing to vicarious action of the inferior rectus and of the deviation will often be successful as to this point. But it is on the examination of the double images that we must chiefly rely for the diagnosis, as follows :—

(*a*) In the whole of the field of vision above the horizontal plane there is single vision. Below the horizontal plane in the median line diplopia appears, the image belonging to the left eye standing lower than that belonging to the right, because the superior oblique being a muscle which assists in rotating the eye downwards, the latter, for want of the action of this muscle, now stands higher than its fellow (right eye). The position downwards and inwards of the eyeballs is that in which the greatest demand is made upon the superior oblique for rotation of the eye downwards : therefore it is in this position its want for this purpose is most felt ; and when the candle is held in this position, the vertical distance between the double images is greatest. (*b*) The superior oblique assists also in rotation of the eye outwards: therefore loss of its power must commit the eyeball to a certain extent to the power of the muscles which move it inwards, and a rotation in this latter direction (convergence) takes place, with the result of making the image belonging to the left eye stand to the left of the image belonging to the right eye (homonymous diplopia). (*c*) The superior oblique inclines the vertical meridian inwards: therefore, in rotation directly downwards, loss of its power commits the eye to the outward wheel-motion imparted to it by the inferior rectus. This gives to the image belonging to the left eye an inclination to the patient's right hand. (*d*) The power of the superior oblique to incline the vertical meridian inwards is greatest when the eye is turned downwards and outwards : consequently, in this respect its paralysis will be most felt in this position, and therefore here the inclination of its image to that of the sound eye will be most marked. (*e*) A remarkable phenomenon eye seems to stand nearer the patient than that of the sound eye. This, it is believed, is due to the fact that the lower image is projected on a plane nearer to the patient, say where it appears to meet the floor.

To sum up, then (*vide* Fig. 186): below the horizontal plane there is homonymous diplopia, while the image (*A*) of the affected eye stands on a lower level, is inclined towards the other image, and seems to be nearer the patient. Furthermore :—

(*f*) In an extreme lower and outer position the image of the affected eye may sometimes seem to stand higher than that of the sound eye, owing to an excessive outward inclination of the vertical meridian, which throws the image on the lower and inner quadrant of the retina.

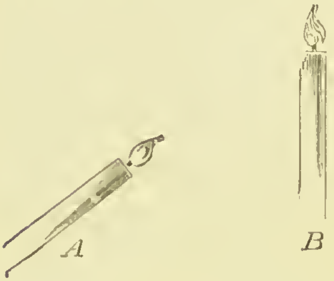

FIG. 186.

In order to do away with or to diminish the diplopia, the patient inclines his head forwards, and turns it to the side of the good eye.

For the prismatic correction of the diplopia, two prisms will be required; one with its base downwards in front of the left eye, to correct the vertical difference, and a second with its base outwards in front of the right eye, to correct the lateral difference.

Paralysis of the Third Nerve (Internal Rectus, Superior Rectus, Inferior Rectus, Inferior Oblique, and Levator Palpebræ).—Complete paralysis of all the branches of the third nerve produces a remarkable appearance. The upper lid droops (ptosis), the eyebrow is raised, from compensatory action of the occipito-frontalis, the pupil is semi-dilated and immovable, the power of accommodation is destroyed, and the eyeball is often slightly protruded, owing to the backward traction of the recti being wanting. Motion inwards exists but to a slight degree, and motion downwards and outwards is effected only by aid of the superior oblique, and is accompanied by marked inward wheel-motion. If the paralysis be of some little standing, the external rectus obtains rule over the eyeball, and rotates it permanently outwards.

The diagnosis, in cases of complete paralysis of all branches of the nerve, is easily made; but not so sometimes, if the paralysis be only slight, and here the examination of the double images is of value, as follows:—

If (see Fig. 187) the left third nerve be partially paralysed in all or most of its branches, there will be crossed diplopia either in the whole of the field of vision—for want of power in the internal rectus—or towards the patient's right at the least, and the lateral distance between the images will increase as the visual object is carried farther towards the right. When the visual object is held aloft the left eye will remain behind—for want of the action of the two muscles which turn the eye upwards—and, consequently, in this position its image will stand, not only to the right of but also above that of the right eye; while, when the visual object is held below the horizontal plane, the eye will—owing to paralysis of the inferior rectus—remain higher than the

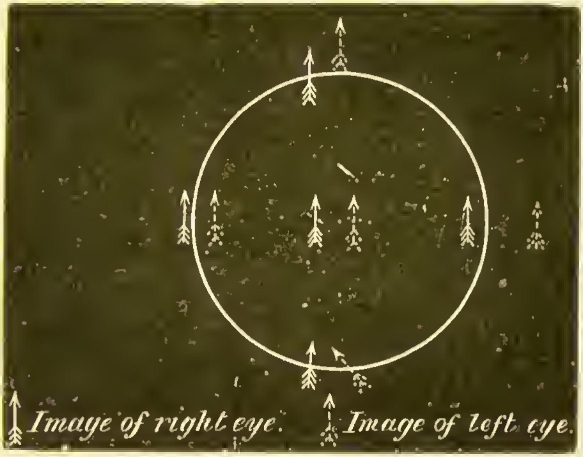

FIG. 187.

right eye, and consequently its image will appear to be lower than that of the right eye. It will, moreover, be inclined towards the latter image, in consequence of the inward wheel-motion imparted to the eye by the healthy superior oblique.

When some branches of the third nerve are paralysed in each eye, the diagnosis is often extremely complicated. The ptosis, however, which is nearly always present, and is readily recognised, and the paralysis of the sphincter iridis (mydriasis) and of accommodation, which often exist, and are also easily observed, give valuable aid. Moreover, any loss of motion upwards must be due to paralysis of the third nerve; but if there be loss of motion downwards, the differential diagnosis between paralysis of the inferior rectus (3rd Nerve) and of the superior oblique (4th Nerve) has to be made. For this see the paragraph on paralysis of the latter muscle.

As may be imagined from the foregoing, it is often difficult in practice to keep clearly before one's mind the different actions of the orbital muscles, and from the character of the diplopia to deduce the paralysis which may be present. The mnemonic diagrams here given (Figs. 188 and 189) will assist in this respect, and they will serve also as a control in reasoning on this subject.[1]

The larger circles in Fig. 188 indicate the position of the cornea resulting from the action of the elevator and depressor muscles of the eye, the smaller central circles represent the pupils. R and R represent the anterior extremities of the axes of rotation of the recti muscles, which lie to the inner side of the cornea, and O and O similarly the extremities of the axis of rotation of the obliques at the outer side of the cornea. The dotted arcs of circles are those described by the centre of the cornea in rotation of the eyes on these axes. The two central arcs with their concavities towards each other represent the action of the recti muscles, and the two outer that of the obliques. The vertical meridian of the cornea, indicated by a line passing through its centre, is tangential to the circles described by the centre of the cornea, and consequently, when one muscle acts at a time, this meridian can only remain vertical in the primary position.

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[1] Fig. 189 is a combination of two mnemonic diagrams which appeared in previous editions of this book. They have been so combined in order to correspond exactly with Fig. 183 illustrating the action of the muscles. (L. W.)

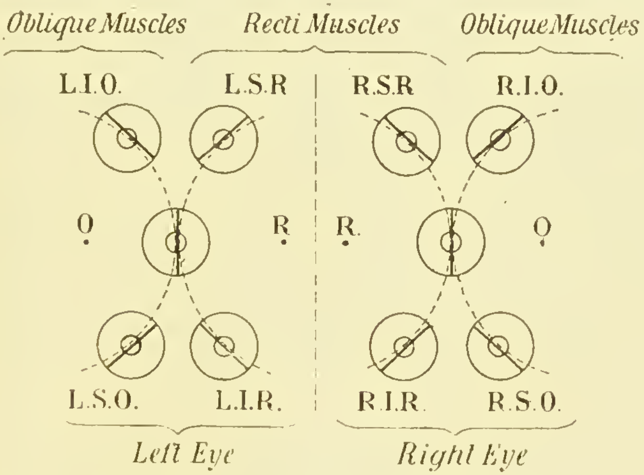

FIG. 188.—Diagram illustrating the separate actions of the elevator and depressor muscles. R.I.O. = Right Inferior Oblique, and so on.

Now, to find the action of the right superior rectus, it is merely necessary to look at the right superior quarter of the centre of the figure (R.S.R.) and it will be seen at once that this muscle moves the eye inwards, upwards, and inclines the vertical meridian inwards. In the same way the action of an oblique muscle will be found in the outer portion of the figure on its own side, but as the vertical action of the obliques is in a direction opposite to that indicated by their names, the superior oblique will be found below and the inferior above. The action of the left inferior oblique is found in the outer portion of the figure, on the left side, above (L.I.O).

Many facts can at once be understood by reference to the figure: for example, that the recti are inward rotators or adductors, and the obliques outward rotators or abductors; that the superior muscles produce inward torsion (R.S.R., L.S.R., R.S.O., and L.S.O.), and the inferior muscles outward torsion (R.I.R., L.I.R., R.I.O., and L.I.O.); also, that the right superior rectus (R.S.R.) for instance, is the true associate of the left inferior oblique (L.I.O.), their action corresponding in all three respects—namely, motion upward, to the left, and torsion to left, and so on.[1]

Now, since the deviation of the eye is in the opposite direction to the normal action of the paralysed muscle, and the projection of the false image is the opposite of the position of the eye, it follows that the false image must appear displaced in the direction of the action of the muscle, therefore Fig. 188 illustrating the diplopia is practically the same as Fig. 189.

In Fig. 189 the form of diplopia which characterises paralysis of each muscle is expressed by the position of the dotted candle bearing the name of the muscle. The dotted lines represent the false images belonging to the affected eye, the continuous lines the true images.

In the case of the recti, the false images enclose a lozenge-shaped space in the centre of the figure, whereas the false images corresponding to the obliques will be found in the outer portions. It will also be noted that the dotted lines extend upwards and downwards beyond the others, indicating respectively that the false images are higher or lower than the true ones. Another fact which the diagram indicates is that, in the case of the muscles represented in the upper halves of the figures, the diplopia occurs in the *upper* part of the field of fixation, or, in other words, in upward movements of the eyes. A similar rule holds good with regard to the lower halves.

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[1] The action of the muscles is considered as if the observer were looking at his own eyes from behind. This view is taken in order that this figure may correspond with Fig. 189, illustrating the diplopia, in which also the observer considers himself the patient. To be quite accurate it should be remembered that as the cornea moves out of the primary position it comes to lie more and more behind the plane of the paper in the figure. In fact the arcs of circles are seen sideways and therefore appear elliptical. The idea of this figure was suggested by Landolt's method of demonstrating the action of the muscles on a rubber ball.

The method of using the diagrams will be better understood by taking a particular muscle as an example. Suppose, for instance, that we wish to know what kind of diplopia results from paralysis of the *left inferior* rectus, it is simply necessary to look at the *left inferior* part of the centre of the figure (recti), which gives the diplopia. If we analyse this we find (1) that the diplopia is *crossed*, for the false image corresponding to the *left* eye is on the *right* of the true image —*i.e.*, the right image corresponds to the left eye; (2) that the false image has its *upper end inclined towards the true one*; (3) that the false image is *lower* than the true

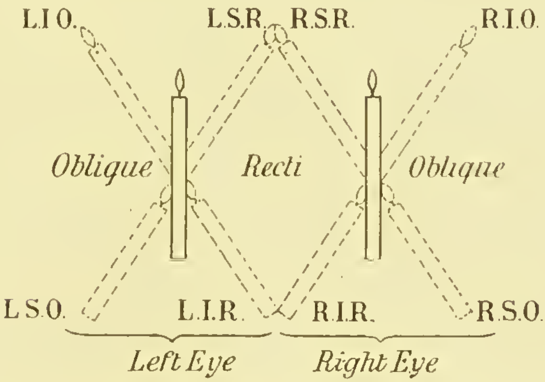

FIG. 189.—Diagram of the diplopia due to paralysis of any one of the elevator or depressor muscles.

one, for the dotted line extends *lower* than the other one; (4) that the diplopia occurs in *downward movements* of the eyes, for it is in the *lower* half of the diagram that the false image lies.

The same method applies to the other recti: the diplopia for the *right upper* rectus is found in the *right upper* quadrant, and so on for the rest.

The diplopia corresponding to one of the obliques will be found in the outer part of the figure on the same side as the muscle, and for the same reason as in Fig. 188 the superior oblique will be below and vice versa. L.S.O. gives the diplopia for the left superior oblique.

The figures can be called to mind either as consisting of the four recti in the centre and the four obliques at the outsides, or as being made up of an × for each eye, with the two recti on the inside and the two obliques on the outside.

This is an extremely simple method. By bearing the figures in mind it is possible to tell immediately what kind of diplopia would result from paralysis of any one of these muscles, and conversely, given the diplopia, to determine to which muscle it is due. Fig. 189 may be used alone, without reference to the action of the muscles, when there is little or no time for thought.

*Some of the paralyses seem to resemble one another very closely in the form of the diplopia produced; for example, paralysis of the left superior oblique, and of the right inferior rectus, in which the diplopia occurs in both cases below the horizontal plane, and the false image is to the left of, and lower than the true one, and inclined towards it. The distinction is made by observing that the false image belongs to the left eye (homonymous diplopia) in the case of the oblique muscle, and to the right eye (crossed diplopia) in the case of the rectus. Figs. 190 and 191 explain this.

Again, as Duane points out, the position of the eye in which the vertical element of the diplopia is at its maximum is of the greatest importance for the diagnosis of the muscle at fault, in the case of the elevators and depressors. In the above cases, for instance, the vertical separation of the images in paralysis of the left superior oblique will be at its greatest, when an attempt is made to turn the eye downwards and *inwards*; and the maximum deviation in this respect, in the case of the left inferior rectus, will be found when the eye looks downwards and *outwards* (see p. 559).

* In case the diplopia does not correspond to any of the recognised forms characteristic of paralysis of any single muscle, the condition becomes complicated, and the solution of the question as to which muscles are at fault is frequently impossible, but there are two very simple causes that may change the nature of the diplopia, and which should be mentioned. In the first place the patient may fix with the paralysed eye, and when this occurs the image belonging to it will seem to him to be in a correct position, and the other will be apparently displaced. It is merely necessary to imagine the diagram of the diplopia in the particular case to be twisted round, so that the image belonging to the paralysed eye will be vertical. For example Fig. 192 in this case would be converted into Fig. 193.

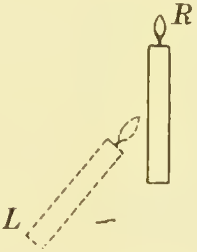

FIG. 190.

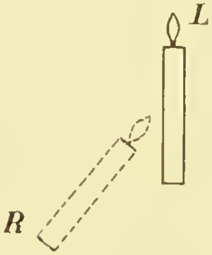

FIG. 191.

Fig. 190.—Paralysis of left sup. oblique. Homonymous diplopia. R. image of right eye. L. image of left eye.

Fig. 191.—Paralysis of right inferior rectus. Crossed diplopia. R, image of right eye. L, image of left eye.

*Again, if paralysis of an elevator or depressor occurs in a patient with a latent horizontal deviation, either convergence or divergence, a crossed or homonymous diplopia may be reversed, on account of the latent deviation becoming manifest in consequence of the impossibility of fusing the images, and thus Fig. 192 would be changed to Fig. 194.

**Measurement of the degree of paralysis* is useful for prognosis, and also for estimating the progress of the case. It may be measured by noting the amount of separation of the double images. Maddox's rod-test with scale is very suitable for this, or the prism required to correct the diplopia may be noted, the deviation being equal to half the angle of the prism. Another method consists in measuring the mobility of the eye, in the direction of the paralysed muscle, with the perimeter.

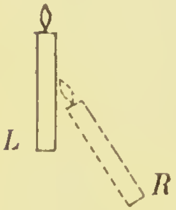

FIG. 192.

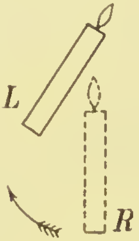

FIG. 193.

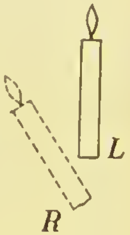

FIG. 194.

The Causes of Peripheral Paralyses of Orbital Muscles are chiefly of rheumatic or syphilitic nature.

Rheumatic paralysis, to which the external rectus is specially prone, will be noted if there be symptoms of general rheumatism, or if there be a history of exposure to cold or wet immediately preceding the attack.

Syphilis will be suggested as a cause, if there be a specific history, and that other causes can be excluded. Peripheral paralyses of the orbital muscles due to syphilis are amongst the later symptoms of the disease, and may depend on exostoses or gummata at the base of the skull, or to syphilitic neoplasms, or meningitis, in the course of the nerve. The third nerve seems to be particularly liable to be attacked by a solitary gumma at the base of the skull, especially at the sphenoidal fissure, ptosis being commonly the first symptom.

Other neoplastic growths can, of course, cause these paralyses in the same way.

Fracture of the base of the skull may be indicated by a 4th nerve paralysis, as the only symptom, due to injury of the nerve as it passes over the apex of the petrous portion of the temporal bone.

Prognosis.—In peripheral paralyses recovery is very frequent; much, however, depending on the nature of the lesion. In cases where a cure is not effected, the diplopia eventually becomes less troublesome and the antagonist muscle often contracted, the eye being then rotated permanently and excessively in the corresponding direction. In cases of old standing, a permanent contraction of the muscles of the neck may be brought about, from the inclination of the head which the diplopia has obliged the patient to adopt.

Treatment.—In these cases the medical treatment consists in drugs suitable to the fundamental disease (rheumatism, syphilis, etc.). Local depletion at the temple by the artificial leech in the early stages, and galvanism later on, may be employed with advantage. The most common method of applying galvanism is through the closed lid; but it is probable that the episcleral method—*i.e.*, with the electrode placed directly over the muscle—is more effectual. A good method is for the surgeon to take one rheophore, well wetted, in one hand, and, securing good contact with the skin of the palm, the index finger is applied to the patient's globe in the situation of the various external muscles of the eye. The finger is covered with a single thickness of well-moistened muslin, and the conjunctiva should be previously rendered insensitive by cocaine. The other rheophore, a moistened plate, is placed on the nape of the patient's neck. The strength of the current advised is from 1·5 to 2 milliampères, and the alternate application and lifting of the finger, by closing and opening the circuit, gives rise to a feeling of a slight electric shock in the terminal point of the finger. The operator should first test the strength of the current upon the patient's cheek. The point of the finger thus employed acts as a sentient rheophore, and can be applied with nicety and delicacy to various parts of the eye, the operator being constantly aware, by the feeling in his finger, of the strength of the current employed.

Passive orthoptic treatment occasionally gives a rapid and brilliant result, while, again, it is useless. It is performed as follows:—The conjunctiva at the corneo-scleral margin, near the insertion of the paralysed muscle, is seized with a forceps, and the eyeball is drawn in the direction of the muscle, and as far as possible beyond its ordinary limit of contraction, and back again. These movements are continued for about a minute once a day, cocaine being used.

Prismatic glasses may be used, either to eliminate the diplopia, or to excite the weak muscle to exert itself. In the former case, the glass selected must completely neutralise the diplopia; but, as it can do so only for one position of the eyes, prisms are rarely employed in this way. In the latter case, a prism slightly weaker than that sufficient to completely neutralise the diplopia is selected, in order that, with a little effort, the weak muscle may be enabled to bring about single vision, and, this effort having been successfully maintained for some days, a still weaker prism is then prescribed, and so on. Since more than a 4° prism in each eye cannot be worn, and the diplopia varies in different positions, the sphere of usefulness of prisms here is very limited.

It is important for the patient's comfort while awaiting his cure, unless a cure by prisms as above described is being attempted, that the affected eye should be covered, so that the distressing double vision may be obviated.

Surgical treatment is justifiable only when, after six months or a year, other means have failed to restore muscular equilibrium. Advancement of the paralysed muscle with, if necessary, tenotomy of the antagonist is indicated. Tenotomy of the associated muscle of the other eye is sometimes performed to establish the equilibrium, but in this case a compensatory movement of the head must take place. This surgical treatment applied to the internal and external rectus sometimes gives satisfactory results; but in the cases of the superior and inferior recti it is less useful. The oblique muscles should not be operated on, but tenotomy of the associated muscle in the opposite eye (in the case of the R. sup. oblique, the L. inf. rectus) may give relief.

A* peculiar and rare form of peripheral or basal paralysis is **Intermitting Paralysis of the Third Nerve of one Eye,** sometimes inaccurately termed **Ophthalmoplegic Migraine.** The patients are generally children or young adults, who usually suffer from headache on the side corresponding to the paralysed eye, and frequently from vomiting. The paralysis may be complete or partial, and the attack varies in its duration from a few days to a few months. Excessive salivation, perspiration, or discharge from the nose occurs in a few cases. Some cases are purely periodical—*i.e.*, in the intervals between the attacks of paralysis all the muscles supplied by the third nerve act in a completely normal manner; while in other cases these muscles, or some of them, do not completely recover their functions in the intervals. There are no visual symptoms such as occur in migraine. We are as yet quite in the dark as to the cause of these periodical paralyses of the third nerve. It is possible that the purely periodical cases are of a functional nature, reflex, or due to recurrent toxæmia, possibly of gastro-intestinal origin, and that the periodically exacerbating cases alone are due to a lesion of the root of the nerve, of an undefined kind, at the base of the skull. In three cases in which an autopsy was made, there was disease of the trunk of the nerve at the base of the skull.

In intermitting paralysis the *Prognosis* of the purely periodical form is favourable, inasmuch as the attacks in the course of time become fewer and less severe, until, finally, they entirely cease. In the exacerbating form the prognosis for complete recovery is less favourable. Out of twenty-six cases collected by Darquier only one patient died, from a cerebral cause.

In view of the obscurity which still surrounds the causation of these intermitting paralyses their *Treatment* must consist, in each case, in the relief of any general dyscrasia or concomitant symptoms which may be present. Purgatives and drinking of hot water have proved of service in some cases.

The third class of paralyses of orbital muscles above enumerated—those due to lesions of the nuclei of the orbital muscles in the aqueduct of Sylvius and floor of the fourth ventricle—are known by the term

***Ophthalmoplegia Externa,** and also as **Nuclear Paralysis**.—The first of these terms was originally employed to denote those remarkable cases in which all, or nearly all, of the orbital muscles of both eyes are paralysed, while the intraocular muscles often remain intact. There can be no doubt, however, that these cases do not differ in their nature from many of those in which, in one eye, several orbital muscles supplied by different nerves—*e.g.*, third and fourth—are wholly or partially paralysed; or where all the orbital muscles in one eye are wholly or partially paralysed; or where in each eye muscles supplied by the same nerve—*e.g.*, both sixth nerves—are wholly or partially paralysed; for such cases are often mild forms of the disease, or else stages in its development. At one time it was considered essential for the diagnosis, that the intraocular muscles should retain their functions, but cases occur in which the sphincter iridis and ciliary muscle are paralysed.

When these two latter muscles alone are paralysed, the condition is called Ophthalmoplegia Interna. When both they and groups of orbital muscles are paralysed, the terms Ophthalmoplegia Interna et Externa, or Ophthalmoplegia Universa, are employed.

The term Nuclear Paralysis indicates any orbital paralysis due to a lesion of the nuclei of the orbital nerves in the pons, and ophthalmoplegia externa comes within this category.

Ptosis, even in cases of complete binocular ophthalmoplegia externa, is often incomplete, and it is remarkable that in some chronic cases, without any improvement in the condition itself, the diplopia, which was at first present, quite disappears.

Occurrence and Progress.—The condition may be congenital, or may make its appearance soon after birth, and may remain permanently without becoming complicated with any further disturbance. Congenital ptosis, which is frequently combined with loss of power in the superior rectus, and is usually binocular, is of this nature. But Nuclear Paralysis is more commonly seen as an acquired condition in childhood, or in adult life, either in an acute or chronic form. Marked cerebral lethargy is often seen with both forms, and the tendon reflexes may be defective.

Acute Nuclear Paralysis is due either to an acute inflammatory process in the nuclei—comparable to the process which produces polio-myelitis anterior acuta, and hence it is called by Byrom Bramwell polio-myelitis acuta—or to hæmorrhagic lesions.

The acute inflammatory cases are apt to have a sudden onset, attended with fever, headache, vomiting, and convulsions, which may subside after a few days, leaving only the ophthalmoplegia behind; and this, too, after a lengthened period, may undergo cure, partial or complete. Transient paralysis of conjugate movements often occur at the beginning of the attack. The intraocular muscles and levator palpebræ are often spared. Sometimes these attacks are complicated with paralysis of the facial nerve, or the diseased process may extend to the spinal cord, and the symptoms of acute polio-myelitis become developed; or, again, acute bulbar paralysis may come on.

Acute peripheral neuritis of the ocular nerves, which is sometimes seen in cases of alcoholic poisoning, may be confounded with acute nuclear palsy. The symptoms of the two states are the same, except that in the case of peripheral neuritis there are no head symptoms at the commencement.

The onset of acute hæmorrhagic ophthalmoplegia is sudden, but is unattended by headache, vomiting, or convulsions. It takes different courses. Sometimes it is rapidly fatal; again, it goes on to softening of the nuclei, and becomes chronic; while, again, it undergoes a slow cure.

It is extremely probable that to this hæmorrhagic class some of the cases of paralysis of orbital muscles belong, which occasionally follow on an attack of diphtheritic sore-throat. These paralyses appear in from one to six weeks after the outbreak of the primary affection. The latter need not have been of a severe kind; indeed, sometimes patients are unaware that they have had a sore-throat. These diphtheritic paralyses always recover in the course of some weeks.

In diabetes, paralyses of orbital muscles are not very uncommon, and are probably to be classed as nuclear. The same may be said of orbital paralyses in lead-poisoning, influenza, and in Gerlier's disease (Vertige Paralysant). Other causes are:—cold, poisoning by nicotine, sulphuric acid, carbonic oxide, and tainted meat.

The Prognosis in all these instances is favourable.

Chronic Nuclear Paralysis (Chronic Polio-encephalitis Superior, of Wernicke) is much more common than the acute form. It depends on a degenerative atrophy of the nerve nuclei, analogous to that which occurs in progressive muscular atrophy and in chronic bulbar paralysis. The onset is gradual, the loss of power in the muscles being at first very slight, but ultimately complete paralysis of the affected muscles results. There is no fever, nor any cerebral symptom. The condition may become associated with chronic bulbar paralysis, with progressive muscular atrophy, or with locomotor ataxy ; but this is not so liable to occur in infants as in adults.

In some cases there may be partial paralysis of the orbicularis palpebrarum, which, according to Mendel, is innervated from the third nerve nucleus through the facial nerve, along with other muscles of the oculo-facial group (frontalis and corrugator supercilii).

Coarse lesions, especially tumours of the pons, of its neighbourhood which press on it, may produce orbital paralyses closely simulating those due to nuclear lesions. But here the paralysis is only one of the symptoms in the case, which are likely to include headache, vomiting, optic neuritis, hemianopsia, hemiplegia, etc. Softenings, patches of disseminated sclerosis, and internal hydrocephalus with over-distension of the aqueduct of Sylvius, are other lesions which may give rise to similar orbital paralyses, but which cannot be regarded as true nuclear ophthalmoplegia. The mode of onset, and the concomitant symptoms, of each case must serve as our guides in arriving at a diagnosis, which will sometimes be difficult enough.

According to Bernheimer, the diagnosis of a nuclear paralysis of the muscles, must take into account the accompanying symptoms, etiology, course of the disease, etc., as the grouping of the affected muscles, whether intra- or extra-ocular, functionally associated or otherwise, is not sufficient in itself to warrant the assumption of a nuclear origin of the affection.

**Conjugate Lateral Paralysis* of the eyes is a symptom which may be caused by a lesion in the pons. It is held that the voluntary motor impulses, coming down from the cortex to produce associated lateral motions of the eyeballs —*i.e.*, action of the external rectus of one eye, along with action of the internal rectus of the other eye—first reach the nucleus of the sixth nerve, and then pass on, through the posterior longitudinal bands, under the corpora quadrigemina, and are connected by neurons with the fibres of the opposite third pair for the supply of the internal rectus of that side. The sixth pair of one side supplies in this way the external rectus of its own side, and also influences the internal rectus of the opposite side; and it is quite probable, that similar connections may exist in the nerve supply of other orbital muscles. Hence a lesion at, let us say, the left sixth nerve nucleus would paralyse the conjugate lateral motions of the eyes towards the left side; and there would in consequence be conjugate lateral deviation of the eyes towards the right—the eyes looking away from the lesion. In conjugate paralysis, or deviation, whether due to a pontine lesion, or, as will be described in a later paragraph, to a cerebral lesion, the combined action of the internal recti for the purpose of convergence of the eyes is retained.

Paralysis of the orbital muscles from nuclear disease may occur in Locomotor Ataxy, Disseminated Sclerosis, General Paralysis, Chronic Alcoholism, and more rarely in Exophthalmic Goitre and Severe Multiple Neuritis.

**Fascicular Paralyses* are mainly distinguished by the presence of other symptoms due to involvement of neighbouring structures. They are rarely symmetrical. Vertigo is common with fascicular third-nerve paralysis, owing to implication of the red nucleus in the tegmentum which is connected with the superior peduncle of the cerebellum. Bernheimer thinks that fascicular and nuclear paralysis are not separable clinically.

*In *Myasthenia Gravis* the symptoms include some which are due to derangement in the power of orbital muscles. It occurs mostly in young people the subjects of malnutrition. Ptosis is a common symptom ; it is usually bilateral and more marked on one side than on the other. It may be constant, or it may only be present towards the latter end of the day, or if the patient looks up for any length of time, when the lids gradually fall. Owing to weakness of the occipito frontalis, their compensatory .overaction, so common in other forms of ptosis, cannot occur. Weakness of the orbital muscles with resulting diplopia is often present. Sometimes one muscle is more affected than others, sometimes there is a general paresis affecting all the orbital muscles, while in some cases complete and persistent ophthalmoplegia externa has been present. An alteration in the relative position of the two images is a striking feature. In some cases irregular nystagmoid movements are induced upon conjugate lateral motion of the eyes. The ocular muscles, as is the case with other voluntary muscles, become readily fatigued, the patients complaining that after reading a few lines the words and letters run into each other. Pupil changes are exceptional, but the pupils are sometimes unequal. In Buzzard's case, after prolonged convergence, the pupils showed a tendency to oscillatory movements. The power of accommodation does not become fatigued.

The general features of the disease are :—Weakness of some or all of the voluntary muscles of the body, which may amount to complete paralysis. After a long rest—*e.g.*, on awaking in the morning—they may respond normally to the will, but become rapidly exhausted after a little use. The affected muscles often exhibit the myasthenic reaction, becoming exhausted by faradic stimulation. The entire system of voluntary muscles may be affected, but those muscles are most apt to be implicated which normally act most constantly, such as the cervical muscles and the extrinsic muscles of the eyeball. The symptoms fluctuate from day to day, or from month to month, and may even disappear for months or even years, and then reappear. There are no sensory symptoms. Death occurs in a large proportion of the cases, but no structural changes have been found to account for the symptoms.

Cerebral Paralysis of Orbital Muscles form the fourth and last of the classes enumerated. They include all the orbital paralyses due to lesions above the nuclei—*i.e.*, in the cortex, corona radiata, or internal capsule. They are usually associated with other symptoms, which aid us in localising, more or less accurately, the lesions which cause them. These paralyses are always physiological, associated, or conjugate, as they are variously and with equal correctness termed—they are, in short, paralyses of motion rather than of muscles.

Conjugate lateral paralysis—loss of power of motion of the eyes to one side or to the other, while the power of convergence of the optic axes is retained—is by far the most common form of this symptom. We do not as yet know where the cortical centre for the associated lateral motions of the eyes is situated.[1] But even if we did know its position, it is not likely that much would be gained so far as clinical localisation of the cerebral lesion is concerned; for this centre, wherever it may be, is extremely sensitive, and is apt to be thrown out of gear by lesions of many different parts of the cortex. Conjugate deviation is, in short, very apt to be a distant symptom, especially in cerebral hæmorrhage, when it is often accompanied by a rotation of the head in the same direction, and lasts only a short time. Moreover, it is thought that, when this centre may happen to be actually involved in the lesion, its function, being largely bilateral, is rapidly taken up by the opposite hemisphere ; and hence, even when conjugate lateral deviation plays the part of a direct cortical symptom, it rarely can be recognised as such, owing to its evanescent character. In paralysing lesions the deviation of the eyes is of course towards the side of the lesion—the eyes look at the cerebral lesion, as Prevost has expressed it—while in irritating lesions the spasm of the affected muscles causes the deviation to be from the side of the lesion. These conditions are the reverse of what happens in conjugate lateral deviation due to lesions in the pons (p. 591), and we are thus enabled to differentiate between lesions in the two positions.

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[1] This centre has been placed by various authors in the inferior parietal lobule (Wernicke, Henschen, Munk, etc.), and in the second frontal convolution (Ferrier, Horsley, and Beevor). Stimulation of the centres of vision in the occipital lobe has also been found to produce conjugate movements (Schæfer, Munk), and these have been regarded as reflex by some; but Knies holds that the visual centre contains the motor centre for the eye-muscles as well. Moreover, it is stated that the visual cortex contains motor pyramidal cells. The latest experiments (Bernheimer) place this centre in that portion of the inferior parietal lobule known as the angular gyrus.

There are four possible cases :—

Cerebral Lesions	Destructive.	Eyes	turned	away from paralysed side.
	Irritative.	,,	,,	towards convulsed side.
Pontine Lesions	Destructive.	,,	,,	towards paralytic side.
	Irritative.	,,	,,	away from convulsed side.

The cerebral cases show that the centre for associated movements is on the opposite side of the brain—*e.g.*, in movements of eyes to the left, the left external rectus and right internal rectus are innervated by the right hemisphere of the brain ; consequently, a destructive lesion here would produce paralysis of the left side of the body and of the associated movements of the above orbital muscles, and therefore the eyes would be drawn to the right by their opponents—*i.e.*, away from the paralysed side. A destructive lesion of the right side of the pons would also, of course, produce paralysis of the left side of the body ; but, involving the right sixth nucleus, it would cause paralysis of the associated movements of the right external rectus and left internal rectus, and, consequently, the eyes would be drawn to the left by the opponents—*i.e.*, towards the paralysed side.

The reverse of the foregoing would occur in irritative lesions. Fig. 195 serves to illustrate the points referred to.

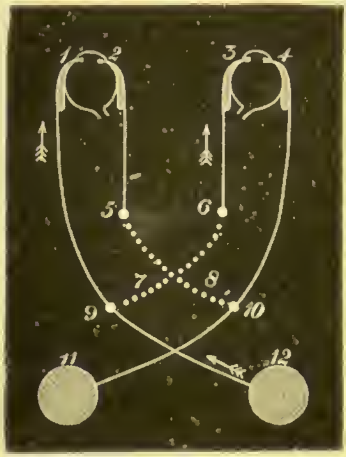

FIG. 195.

1. Left Ext. Rectus; 2. Left Int. Rectus; 3. Right Int. Rectus; 4. Right Ext. Rectus; 5. Nucleus left third nerve; 6. Nucleus right third nerve; 7 and 8 Post, longitudinal bands from sixth nerve to opposite third nerve; 9. Nucleus left sixth nerve; 10. Nucleus right sixth nerve; 11 and 12. Left and right cortical centres. An impulse starting from 12 would travel down to 9, and produce an associated movement of the eyes to the left.

A destructive lesion at 12, the right cortical centre, involving also motor centres of the body, would cause left hemiplegia; and, since the external rectus of the left eye and internal rectus of the right eye would be paralysed, the antagonists would turn the eyes to the right—*i.e.*, away from the paralysed side. A destructive lesion of the right side of the pons, also producing left hemiplegia, if it involve the sixth nucleus, will produce paralysis of the external rectus of the right eye and of the internal rectus of the left eye, and the antagonists would turn the eyes to the left—*i.e.*, towards the paralysed side. It is easy to see how irritative lesions would produce exactly the opposite effects.

When the acute symptoms have passed off, the conjugate deviation, due to irritation, disappears even though a conjugate paralysis and hemiplegia may remain.

Hemianopsia interferes to a certain extent with the conjugate movement towards the affected side, in so far as this is guided by visual impressions. According to Knies, the difficulty in reading in right hemianopsia is mainly due to this cause.

Conjugate deviations have been found with disease of the middle peduncle of the cerebellum of the pons, corpora quadrigemina, optic thalamus, and cerebral cortex.

It seems important here, even at the risk of some repetition, to direct special attention to

***The Localising Value of Paralyses of Orbital Muscles in Cerebral Disease.**—*Paralysis of the Third Nerve.* As regards this nerve we are struck with the fact that ptosis, partial or complete, may be present as a focal symptom in cortical lesions—cerebral ptosis, as it is called—without any other third-nerve branch being paralysed. That a separate cortical centre for this branch of the third nerve exists, and that it innervates the muscle of the opposite side, is very probable. The existence of such a centre would not be inconsistent with the view that, as regards the motions of the eyeballs, associated centres alone are present; for, although as a rule the elevators of the lids are associated in their motions, yet by an effort of the will most people can throw one of them into motion separately, or more than the other. No doubt the power to voluntarily innervate one levator and orbicularis alone varies in different individuals, and in many persons the levator centres are practically associated centres, and probably this is the reason why cerebral ptosis is rather rare. The position of this centre is still an open question, but it is believed to be situated in front of the upper extremity of the ascending frontal convolution close to the arm centre.

Ptosis, then, has no value as indicating the locality of a lesion in the cortex; but it may be of use in distinguishing a cortical lesion from one situated elsewhere in the brain, for monolateral ptosis, as the only focal symptom, occurs with cortical lesions alone.

It is probable that ptosis, as the result of a cortical lesion, is a distant symptom in not a few of the cases where it is present.

Ptosis on the side of the lesion has occasionally formed a symptom in disease of the pons, without paralysis of the other branches of the third nerve—except, sometimes, in so far as conjugate deviation (*vide supra*) is concerned—and without the third nerve being involved in the lesion.

Again, ptosis, by forming a factor of a crossed paralysis, may serve to localise a lesion in the crus cerebri. When the third nerve is paralysed by a lesion in this situation it is the rule to find it paralysed as a whole; but paralysis of only some of the third-nerve branches may be produced by a lesion of the cerebral peduncle, and the branch to the levator palpebræ seems to be the one most frequently implicated alone.

To complete the subject of ptosis, mention must be made of *Sympathetic Ptosis* which is accompanied by other eye-symptoms, as well as by symptoms of vasomotor paralysis of one side of the body, such as elevation of temperature, and redness and œdema of the skin. In these cases, there is (1) apparent ptosis on the paralysed side, owing to the contraction of the palpebral aperture, but the lid can be raised; (2) contraction of the pupil on the same side; (3) diminished intraocular tension; (4) a shrinking back of the eyeball into the orbit, so that it seems to have become smaller; (5) an abnormal secretion of thin mucus from the corresponding nostril, of tears from the affected eye, and of saliva from the corresponding side of the mouth. In the later stage, the side of the face becomes paler and thinner, its temperature is lower, and it perspires less than the other side, or not at all. This train of symptoms has been found in lesions of the corpus striatum, but is chiefly due to lesions of the cervical sympathetic, or of the spinal cord at or above the level of the eighth cervical and first dorsal nerve, or of these nerves alone.

A common sign of disease of the crus cerebri is what is known as *crossed hemiplegia.* Paralysis of the third nerve, on the side of the lesion, with hemiplegia, hemianæsthesia, often facial, and sometimes hypoglossal, paralysis on the opposite side of the body is a frequent form of it. The lesion may implicate all the branches of the third nerve, or only some of them. But the localising value of crossed hemiplegia, as Hughlings Jackson long ago pointed out, depends chiefly on the hemiplegia and paralysis of the cranial nerve coming on simultaneously. If they occur at different times they may be due to two distinct lesions, neither of which may be in the crus; for the hemiplegia might be due to a lesion in the hemisphere, and the third-nerve paralysis to a basal lesion of earlier or later date. Yet a few cases have been observed where, with a lesion in the cerebral peduncle, the third-nerve paralysis preceded the hemiplegia by a considerable interval.

That basal lesions are by far the most frequent cause of paralysis of the third nerve is beyond a doubt: and here it is usual, but not constant, to find it paralysed in all its branches. The diagnosis to be made, when direct symptoms are being considered, is, for the most part, between a lesion in the crus and a lesion at the base. We cannot pretend to be able to make this diagnosis with certainty in all cases. Complete paralysis of every branch of the third nerve without any other paralysis is almost always basal; so also are those cases in which, where there is hemiplegia, it is slight, as compared with the degree of the third-nerve paralysis; and those cases, too, to which reference has already been made, where there is an interval between the onset of the paralysis of the extremities and of the third nerve, are apt to be basal. Of course there may be such a combination of paralyses of the other cerebral nerves with that of the third nerve, as to leave no doubt with reference to the basal position of the lesion.

The third nerve may be paralysed by lesions in the interpeduncular space, in which case the paralysis may be partial (ptosis alone, or abolition of upward and downward motion alone), complete, monocular, or binocular. When both nerves are affected there is generally also paralysis of the other orbital nerves, or of the facial nerve; and hemiplegia or hemianopsia may also be present.

Thrombosis of the Cavernous Sinus invariably produces paralysis of the third nerve; but all the orbital nerves, as well as the fifth and the optic nerve, may also be involved, giving rise to complete immobility of the eye, with loss of conjunctival and corneal sensation. The pupil is usually contracted at first, but later on dilates. The venous obstruction causes exophthalmos, œdema of the lids, and chemosis. The ophthalmoscope sometimes shows the presence of congestion papilla. The general symptoms are rigors, high temperature, and vomiting. Its principal causes are infective inflammation of the orbital cavity; erysipelas of the face; infective inflammation in the buccal, nasal, and pharyngeal cavities, and of the body of the sphenoid; and extension of thrombosis of the sinuses from purulent otitis. The thrombosis in more than half the cases spreads to the other side through the circular sinus. When the invasion occurs from the intracranial direction, pain in some or all of the branches of the first division of the fifth nerve is usually an early symptom.

Third-nerve symptoms—in addition to those included under the headings conjugate deviation, or paralysis, and ptosis—are sometimes distant symptoms. Tumours of the cerebral hemispheres, more particularly if accompanied by violent general head symptoms, indicating probably high intracranial pressure, are the lesions most apt to produce these distant third-nerve symptoms. As a rule, the slighter the general cerebral symptoms, the more likely are the third-nerve paralyses to be direct symptoms. This rule, indeed, applies to other as well as to third-nerve focal symptoms.

Paralysis of the Fourth Nerve, when combined with paralysis of other motor eye-nerves, is difficult to recognise; and consequently in such cases it furnishes but little aid for localisation. Solitary paralysis of this nerve as a symptom of cerebral focal lesion is extremely rare. Nieden has placed a case on record in which paralysis of one fourth nerve was the only focal symptom to which a tumour of the pineal gland, of the size of a walnut, gave rise. But the isolated fourth-nerve paralysis is more apt to be produced by a basal lesion. Pfungen has pointed out that, in meningitis, exudation in the space between the corpora quadrigemina and the splenium of the corpus callosum may implicate the fourth nerves in the valve of Vieussens, and believes it is prone to do so in tubercular meningitis. In combination with paralysis of the third nerve it speaks for a lesion in the cerebral peduncle, extending back to the valve of Vieussens.

When *Paralysis of the Sixth Nerve* occurs as the only focal sign it is probably due to disease at the base, or it is a distant symptom. There is no cranial nerve so liable to provide a distant symptom as the sixth. Gowers refers this liability to the lengthened course these nerves take over the most prominent part of the pons, which renders them readily affected by distant pressure. One or both nerves may in this way be paralysed. Wernicke states that sixth-nerve paralysis is most apt to be present as a distant symptom, when the lesion, especially a tumour, is situated in the cerebellum; differing in this way from the third nerve, which is more likely to give distant symptoms with a lesion in the cerebral hemisphere.

Paralysis of the sixth nerve, simultaneous in its onset with hemiplegia of the opposite side of the body, indicates a lesion in the pons, usually a hæmorrhage, on the side corresponding to the paralysed nerve. We know that the fifth and facial, and sometimes the auditory, spinal accessory, and hypoglossal nerve, may all, in varying combinations, form one of the elements in a crossed paralysis from a lesion in this position; but, if special localising value is to be given here to the participation of any one cranial nerve, that nerve is the sixth. The paralysis of this nerve, simultaneously with palsy of the opposite side of the body, while other conditions point to an intracranial lesion, speaks, then, almost certainly for pontine disease.

Basal paralysis of the sixth nerve is frequently double, especially in syphilis. Fracture of the apex of the petrous portion of the temporal may also cause it.

Paralysis of the facial with the sixth is not an uncommon combination caused by a lesion in the pons, which at the same time produces hemiplegia of the opposite side of the body. This combination is a natural one, in view of the close relations of the nuclei of the sixth and seventh nerves. The manner in which the root of the facial nerve winds round the sixth-nerve nucleus must also have an important bearing on the occurrence of associated paralyses of these nerves. (See also p. 299.)

Hemiplegia due to a lesion of the cortical motor region, which might happen to be combined with paralysis of the sixth nerve as a distant symptom, offers no difficulty in its diagnosis from hemiplegia with sixth-nerve paralysis in pontine disease; for, while in the latter the paralysis is crossed, in the former it is homonymous.

Paralysis of the Seventh Nerve. When lagophthalmos occurs as a symptom in focal cerebral disease, it is useful in localising the disease by assisting in differentiating a lesion in the internal capsule, or in the facial motor centre of the cortex, from one implicating the portio dura in the pons, as it is absent, or very slight, in the former cases, but very often markedly present in the latter. With a lesion in the lower part of the pons we are apt to have lagophthalmos with crossed hemiplegia; but if the lesion be in the upper part of the pons—the fibres from the opposite side having here joined the motor tract—the hemiplegia and lagophthalmos will be homonymous.

Paralysis of the Fifth Nerve, with hemiplegia of the opposite side, points to disease in the pons. Neuroparalytic ophthalmia is said to be the rule in basal lesions of the fifth nerve, and to occur very rarely in nuclear or fascicular lesions.

The *Orbicular Sign* may be noticed in some attacks of apoplexy with hemiplegia after consciousness has returned. It consists in this, that the hemiplegic person, who during health has been able to close each eye separately, and who even now can close both eyes together, or the eye on the sound side alone, is unable to close the eye on the paralysed side by itself. This sign usually passes away after a short time. Sometimes when both eyes are closed it requires a greater effort to bring the eyelids together on the paralysed side.

Extensive basal lesions, especially those due to syphilitic disease, may produce symptoms due to involvement of widely separate structures, without interfering with those which intervene; hence they tend to implicate several nerves without reference to system or function.

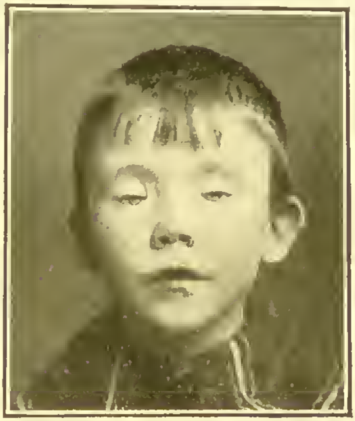

FIG. 196.—Congenital ptosis with epicanthus.

***Congenital defects of motion** of the eyes are not very uncommon, and are sometimes hereditary. Ptosis (pp. 292 and 299) with, or without defect of upward movement of the eyeballs, is the commonest form, and is often associated with epicanthus (Fig. 196), but all degrees of impairment of mobility, and even total loss of motion, may be met with. In paralysis of outward movement, retraction of the eyeball occurs in some cases on looking inwards. The power of convergence is frequently retained, although lateral movement may be impaired or absent. The pupils and accommodation escape as a rule. There is no diplopia or secondary deviation as in acquired paralysis. (According to Duane secondary deviation does occur.) Vision is usually impaired, and the patients are often mentally dull. The defective mobility is due to absence or defect (aplasia) of the muscles, nerves, or nuclei.

CONVERGENT CONCOMITANT STRABISMUS (NON-PARALYTIC STRABISMUS).

This is the condition which is popularly known as inward 'cast' or 'squint.' It makes its appearance in children, when they begin to take an interest in small objects, such as toys and pictures; or a little later, when the first lessons are learned—in short, when they begin to make frequent and prolonged demands on their internal recti and accommodation, most commonly from the age of three to six years.

The term 'concomitant' (*concomitatus*, accompanied) is given to it in contradistinction to 'paralytic' strabismus; because in it the squinting eye accompanies the straight one in all its movements to an equal extent. In the primary position of the eyeballs, in a case of concomitant squint, the parallelism of the visual axes is defective, and, as the eyes are moved from side to side, the defective parallelism continues in the same degree, neither increasing nor decreasing. Moreover, the secondary deviation (see p. 571), in the sound eye, in these cases of concomitant strabismus, is equal in degree to the primary deviation of the squinting eye; because the internal rectus of the good eye being associated in its action with the external rectus of the squinting eye, when the latter muscle is forced to roll its eye outwards in order to bring it to fixation, the internal rectus of the good eye, receiving a similar nervous impulse, rolls that eye inwards to the same extent as the squinting eye has been rolled outwards. The good eye will therefore present, under the covering hand, an internal strabismus of the same amount as that which had previously been present in the squinting eye. This is an important point, for it is an aid in the differential diagnosis of this form of strabismus from the paralytic form, in which the secondary deviation is greater than the primary one (see General Principle No. 2, p. 571). Diplopia and giddiness are absent in non-paralytic strabismus.

In concomitant strabismus, both eyes never squint simultaneously, as one hears it sometimes stated by parents; although the excessive convergence, as will be explained later on, is present in both.

The method of distinguishing which is the squinting eye is given on p. 565.

Donders pointed out that, in a large proportion of cases of convergent strabismus, the refraction is hypermetropic; and he drew the conclusion that hypermetropia is to be regarded as the cause of the strabismus in the following way:—It has been shown (p. 29) that with each degree of normal convergence of the optic axes, for the purpose of single vision, a certain effort of accommodation, in order to see the object distinctly, is associated. The greater the angle of normal convergence, the greater is the possible effort of accommodation.

Of this physiological fact, Donders said, the hypermetrope often unconsciously takes advantage, and, in order to brace up his accommodation in an excessive degree for the sake of distinct vision with one eye, he increases the angle of convergence of the optic axes.

The over-convergence is not, however, as usually described, limited to the squinting eye; both take part in it, and the effect is to render the strabismus manifest in the eye which does not fix. To explain this it may be desirable to consider what occurs, when convergence and accommodation are normal. In Fig. 197 the eyes are converging on, or fixing, the point O, and the object is seen singly, and at the same time distinctly, because the amount of accommodation required is normally associated with this degree of convergence. Although the right eye (R) is in the primary position, it is taking part in the act of convergence as much as the left eye (L). If O were at O′, at the same distance from the eyes but in the middle line, L and R would converge through equal angles, *a* and *b*. Now, if the eyes make a lateral movement to the right (arrow 3), the deviation of L would be made up of the angles *a* and *c*, *a* being due to convergence, and *c* to the lateral movement in the same direction, both brought about by the left internal rectus; whereas the convergence in R, due to the internal rectus, is neutralised by the lateral movement which is in the opposite direction in this eye. If this eye had not been converging, it would have remained parallel to L in the lateral movement, and would have moved outwards. L is considerably rotated inwards, but it is not squinting, because it is fixing O.

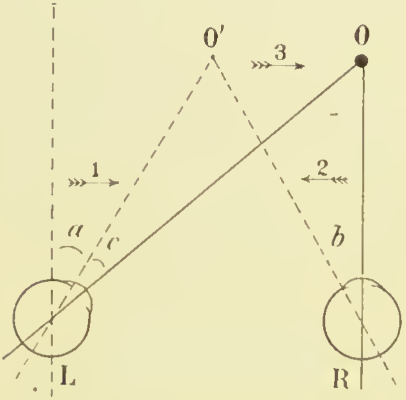

FIG. 197. Binocular fixation with convergence and accommodation for O.

Fig. 198 represents concomitant convergent strabismus. The patient wishes to see the object at O distinctly, but owing to his hypermetropia, the accommodation normally associated with this degree of convergence is not sufficient.

By converging for a nearer point (B) an additional effort of accommodation can be made, but then the patient could not fix O, and it would appear double. In order to avoid this dilemma a lateral movement of the eyes is made from B to B′, and thus the right eye (R) is brought into line with O, and sees it distinctly by means of the additional accommodation gained by convergence for B. The left eye now no longer fixes O, and therefore squints. The deviation of the squinting eye is made up of the angles *a* (excess of convergence for B) and *e* (lateral movement to B′). In the right eye, the excess of convergence is neutralised by the lateral motion in the opposite direction. In fact, it is only the desire for fixation which keeps both eyes from squinting.

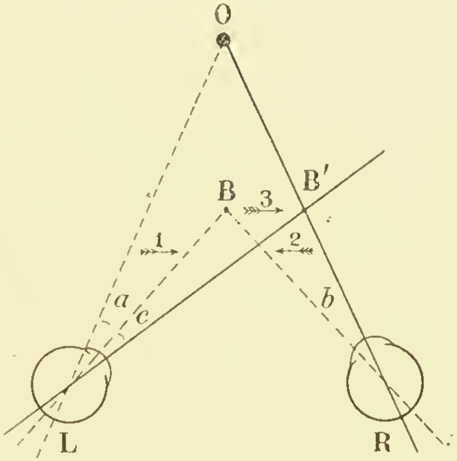

FIG. 198.—Concomitant convergent strabismus; binocular convergence for B′ with monocular fixation and accommodation for O.

Inasmuch as all hypermetropes do not squint, Donders considered that there were contributing circumstances, which caused each hypermetrope to unconsciously decide between distinct monocular vision with strabismus, and indistinct binocular vision. The latter, he said, is likely to be preferred if the condition of the refraction and the acuteness of vision is the same in each eye; while, if one eye be amblyopic, or if the retinal images differ much, by reason of one eye being more ametropic than its fellow—from nebulous cornea, or from other causes—the desire for binocular vision would be less strong, and the imperfect eye would deviate inwards for the sake of the resulting increase of accommodation in the perfect eye.

It is admitted that hypermetropia is one of the causes of internal strabismus, but it is not the only cause, and probably not even the principal cause, for the following reasons:—(1) If Donders' theory be complete, convergent strabismus must always appear, whenever there is binocular hypermetropia, along with the conditions which reduce the value of binocular vision. But strabismus is often absent, while the degree of ametropia is markedly different in the two eyes, or while the acuteness of vision is very defective in one eye. Again, the number of cases of strabismus is very small in proportion to the number of hypermetropes, since nearly all children are hypermetropic. (2) In periodic strabismus, the influence of hypermetropia and of the accommodative effort is very evident; and yet these cases only go to show that, while hypermetropia is very frequently one of the causes of strabismus, it is not the only or most important one; for here, clearly, some factor necessary for the production of a permanent squint is wanting. (3) Donders' theory fails to explain the occurrence of convergent strabismus in emmetropic and in myopic individuals, where, of course, no excessive effort of accommodation is required.

The fact that very few squinters are found amongst high hypermetropes is not an argument against Donders' theory, as high degrees of this error are met with much less frequently than low or moderate degrees.

Congenital want of equilibrium between the muscles has been advanced as an explanation of convergent squint, but no proofs of this preponderance of certain muscles can be given.

Spontaneous cure of strabismus sometimes takes place, most commonly between the tenth and sixteenth year of age. That it may happen with hypermetropia, and with defective vision in one eye, is strongly against Donders' theory, assuming, of course, that the hypermetropia has not diminished much, as it naturally tends to do at this time of life.

The most likely cause is to be found in a defective development of the sense of fusion (p. 565), aided or caused by conditions which render fusion more difficult, such as hypermetropia, or amblyopia, either congenital, or acquired in early life. Illness may weaken accommodation, and the temporarily altered relation between the latter and convergence may cause a squint to appear, if the sense of fusion be weak, even in emmetropia. In alternating strabismus, where the patient squints with either eye, the vision is generally good and equal in both eyes; yet, according to Worth, the faculty of fusion is always wanting in these cases.

* *Single Vision in Concomitant Convergent Strabismus.*—For the most part these patients do not complain of double vision, as in cases of paralytic strabismus. Why is this? The image of the object looked at, it will correctly be said, must be formed in the squinting eye in each of these kinds of strabismus, on a part of the retina not identical with that in the fixing eye, but lying to the mesial side of it; and hence the image of the object should be projected by the squinting eye to its own side of the true position of the object (homonymous diplopia), and the latter should therefore be seen doubled. It is seen doubled in the paralytic form; why not also in the concomitant form? The only explanation of this circumstance, which, until within the last few years, had been put forward, was, that convergent concomitant strabismus being a quasi-physiological condition, the patient's mind involuntarily suppresses the annoying image belonging to the squinting eye, in a manner analogous to that by which, when we are deeply interested in conversation, all extraneous sounds are unperceived, although they, too, must reach the nerve of hearing. This suppression of the image belonging to the squinting eye

was believed to be the more easy owing to the indistinctness of the image itself, formed as it is on a peripheral part of the retina, while in the good eye it falls on the macula lutea. We often find, moreover, that the squinting eye is *ab initio* more defective (macula cornea, higher degree of hypermetropia, astigmatism, etc.) than its fellow, and it was held that this, too, rendered suppression of its image more easy. Such a suppression of the image is possible, and it no doubt does occur in many cases of strabismus; but it is certain that it does not occur in all of them, perhaps not even in most of them. To go into the arguments on this point would be beyond the scope of this handbook. Suffice it to say that, in those cases where suppression of the image of the squinting eye does not take place, a certain degree of participation in the act of vision on the part of this eye, when not too blind, is implied. One of two events takes place in those cases:—Either the region of the retina, on which, in the squinting eye, the image of the visual object is formed, becomes functionally developed into a spot to a great extent physiologically 'identical' with the macula lutea of the straight eye, and then something approaching normal binocular fusion of the images comes about, and hence single vision; or else diplopia is actually present, although, as a rule, it passes unnoticed by the patient, owing to its having become habitual to him. In some cases the first of these conditions is the actual state, in others it is the second which exists. In support of the first is the occurrence, not rarely observed, of crossed diplopia after operation for concomitant convergent strabismus, even when there is no divergence produced; and in support of the second, the diplopia which intelligent patients often admit, when they are carefully examined with the aid of a red glass before the good eye.

* *Amblyopia of the Squinting Eye.*—In a large proportion of the cases of internal concomitant strabismus the squinting eye—seen where there is no marked astigmatism, and where

the media are clear—is amblyopic. It has been a very generally accepted opinion that this amblyopia is due to want of use on the part of the squinting eye, in consequence of the suppression of the image on its retina, and hence it is termed amblyopia ex anopsiâ. According to Schweigger, if this view were the correct one, we ought always to find only slight amblyopia of the squinting eye in children soon after strabismus comes on; while it should be of high degree—in fact, the eye should be almost useless—in adults who have not been operated on, and in whom monolateral strabismus had been present since childhood. And yet marked amblyopia may often be found in children in the squinting eye, while in adults the squinting eye often has very good vision—in short, the amblyopia of the squinting eye is not progressive, as it would be were it ex anopsiâ. Again, many squinting eyes, when the straight eye is covered, instead of fixing the visual object with the macula lutea, remain unchanged in position, or even turn inwards more than before (amblyopia with excentric fixation); and in less well-marked cases of the same sort, although there is no excentric fixation, yet the preference for fixation with the macula lutea is lost, and uncertainty of fixation results, no one part of the retina being more useful for that purpose than another. It is held by many that this form is characteristic of amblyopia ex anopsiâ, and is the result of the strabismus; but it is identical with a form of congenital amblyopia, sometimes present without strabismus in one eye only. Worth, however, points out that in these cases there is a greater error of refraction in the amblyopic eye, and that even in spite of the amblyopia the fusion sense is well developed. A strong argument in favour of amblyopia ex anopsiâ is the improvement which often seems to take place in the vision of the squinting eye by systematic separate use, or after the strabotomy. Schweigger thinks that, where the improvement takes place, the defective vision has been due rather to retinal asthenopia than to amblyopia; and if, at the outset, patients be pressed to discern the test-types, they often succeed in producing a better acuteness of vision than they at first seemed to possess. In many cases separate use fails altogether in improving the vision of the squinting eye, even when it is not very defective—a fact which is unfavourable to the amblyopia ex anopsiâ theory. The circumstance that in alternating strabismus the sight of each eye is good, cannot be regarded as proof in favour of amblyopia ex anopsiâ. Schweigger believes that the amblyopia in the squinting eye is congenital; and, far from being the result of the strabismus, is a factor in its production, just as opacities of the cornea, or high degrees of ametropia, have always been admitted to be. The views of different observers vary greatly on this point, and depend very much on the age of the patient when first treated, on the methods employed for testing and developing the vision, and on the perseverance of the surgeon, and of the patient's parents.

Priestley Smith upholds the theory of the defective development of the sense of fusion, which sense is acquired, as stated before, in infancy. During the first few years of life, this newly acquired faculty is less stable than at a later period, and is more easily disturbed. Hence the greater liability to strabismus in infancy. Among three hundred and forty-seven cases, where the onset age was ascertained, two hundred and fifty-four, = 73 per cent., began before the children were five years old. Three years old was the most common age. The hypermetropic child is specially liable to convergent strabismus, because he has to overcome a special difficulty: he must learn to converge normally, while he accommodates abnormally. Failing in this, he squints in order to see clearly. Many squints arise in this way, but the influence of hypermetropia must not be exaggerated.

Infantile disorders—convulsions, whooping-cough, measles, a fright, a fall, etc.—are often the starting-point of strabismus, because the controlling influence of the higher brain centres is weakened at such times. Priestley Smith believes that a continuous squint involves weakening or loss of visual function, and that the younger the child the more readily does this occur. The sense of fusion, being no longer exercised, is gradually lost, and may prove irrecoverable a few years later, even though the eyes be put straight. Further, an eye which never fixes the object at which the patient looks, loses the power of true fixation. Such loss is found most often amongst cases of early onset and long duration ; it is rarely, if ever, found until the squint has become continuous for at least six months. Again, it is probable that the early onset of strabismus, with complete disuse of the squinting eye, may arrest the development of form-perception in the latter, and thus render it permanently amblyopic.

Worth's views are similar to Priestley Smith's. He believes that the power of central fixation is lost very rapidly in infancy, and that the earlier the onset of the strabismus the greater will be the amblyopia. After six years of age, amblyopia ex anopsiâ seldom takes place to any great extent. This weakens Schweigger's argument based on the non-progressiveness of the amblyopia.

There are *Three Clinical Varieties of Convergent Concomitant Strabismus.*—(1) Periodic. (2) Permanent alternating. (3) Permanent monolateral. Periodic strabismus occurs only now and again, perhaps when a greater effort of accommodation is required. It sometimes is the first stage of permanent monolateral, or of alternating strabismus ; but these two latter forms do not always have their beginning in the periodic form, which often continues as periodic to the end of the chapter. In alternating strabismus the patient squints with either eye indifferently. In permanent monolateral strabismus the squint is confined to one eye.

Measurement of Convergent Strabismus.—The amount or degree of the deviation of the squinting eye is measured by one of the following methods. In all of them it is important that the patient be directed, during the test, to regard an object placed in the median line and on a level with his eyes (the Primary Position, p. 558). The angle of the squint usually increases with accommodation when the object of fixation is near.

1. Hirschberg's Method consists in making the patient fix a candle flame, or the ophthalmoscopic mirror, held straight in front of, and about a foot from, the eyes, when the observer estimates the degree of deviation by the position of the corneal reflex. Where there is no squint, this reflex is situated at, or (with large angle γ) slightly to the inner side of, the centre of the pupil in each eye. In a convergent squinting eye it is displaced outwards, and Hirschberg recognises five groups of strabismus. Group 1 (Fig. 199 representing the right eye), in which the reflex is nearer to the centre than to the margin of the pupil. This represents a strabismus of less than 10°, and no operation is indicated. Group 2, in which the reflex is at or about the margin of the pupil, representing a strabismus of 12° to 15°, and indicating a simple tenotomy, with occasionally a tenotomy of the other internal rectus. Group 3, in which the reflex is outside the

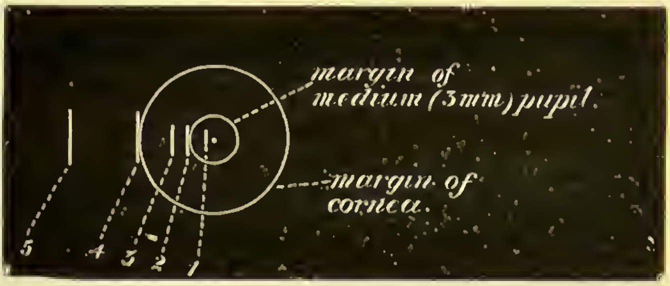

FIG. 199.

pupillary margin, about half-way between the centre of the pupil and the corneal margin. This represents a strabismus of about 25°, and indicates a tenotomy of the internal rectus, combined with a moderate advancement of the external rectus. Occasionally, later on, a tenotomy of the other internal rectus will be required. Group 4, in which the reflex is on or near the corneal margin; representing a strabismus of 45° to 50°, and indicating a tenotomy of the internal rectus, along with energetic advancement of the external rectus, and sometimes a later tenotomy of the other internal rectus. Group 5, in which the reflex is on the sclerotic, between the margin of the cornea and the equator bulbi. This represents a strabismus of 60° to 80°, and requires the combined operation, with strongest possible advancement of the externus. Even this is sometimes insufficient, and a tenotomy of the internal rectus, or even the combined operation on the other eye, may be subsequently required. This is a modification of the linear method, and is a convenient one in routine practice.

2. Priestley Smith measures strabismus by means of a double tape (Fig. 200), used in conjunction with the ophthalmoscope, as shown in the accompanying figures. The patient places the ring *P* on one of his fingers, and holds it to his cheek. The observer places the ring *O* on the forefinger of the hand which holds the ophthalmoscope; this keeps his eye at a distance of one metre from the patient's face. He uses his disengaged hand as a fixation object for the patient, holding it edgewise towards the patient, and letting the graduated tape slide between his fingers. A small weight at the end of the tape keeps it stretched, as the hand moves in either direction.

Fig. 201 illustrates the measurement of a convergent strabismus of the right eye. The patient, seated below the lamp and holding the tape as above described, is told to look at the mirror. The observer, holding the ring *O* and the mirror in the right hand, throws the light on the patient's left eye (*L*)—*i.e.*, the fixing eye. He sees the corneal reflex in the centre of the pupil, and knows thereby that this eye is fixing properly. He then throws the light on the right eye (*R*), and sees the reflex situated eccentrically outwards, and knows that this eye deviates inwards. Taking the graduated tape between the fingers of his left hand, and telling the patient to watch this hand, he moves it outwards along the tape (see Fig. 200), and meanwhile watches the corneal reflex in the deviating eye. When this latter reaches the middle of the pupil he reads the position of the hand upon the tape. The axis of the deviating eye (*R*) has moved from *R′* to *O*, through the angle *R′ R O*. The axis of the non-deviating eye (*L*) has moved through an equal angle (*O L L′*). The angular movement of *L*, as measured by the tape, equals the angular deviation of *R*.

Fig. 200.

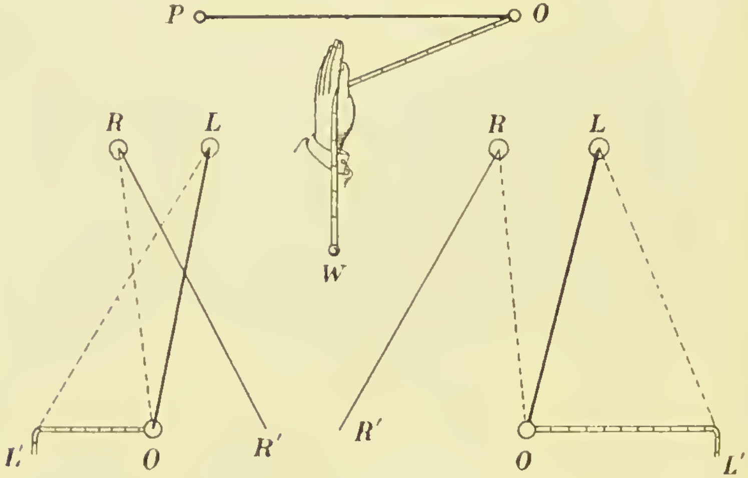

Fig. 201. Fig. 202.

Fig. 202 illustrates the measurement of a divergent strabismus of the right eye. The hands must be reversed, but the principle is the same as before.

Maddox's tangent scale, and Worth's deviometer in which an electric light is flashed on the cornea, are based on the same principle, and are very useful, the latter especially so, for infants.

The graduated tape is a substitute for a graduated arc of a circle, but does not exactly correspond with such an arc; the error involved is, however, so small as to be of no importance, if the observer keep each of his hands at about the same distance from the patient's face. In this mode of measuring a strabismus it is the excursion of the fixing eye which is actually measured, and the excursion of the deviating eye is taken to be equal to it. If the excursions of the eyes be unequal, the result is faulty. The method, though difficult to explain in words, is very quick and satisfactory in practice.

3. Perimeter Method.—The object aimed at here is to determine the size of the angle, which the visual axis of the squinting eye makes, with the direction it should normally have. For this purpose a perimeter is employed. Let us suppose that the right eye (*R*, Fig. 203) be the squinting eye, and that *P o P* be the arc of the perimeter. The patient is placed at the instrument, as though the field of vision of his squinting eye were about to be examined. He is directed to look at a distant object (*A*) with his good eye (*L*). The visual line from *R* should now pass through the point *o*, but it passes through the point *n*, and therefore *o R n* is the angle of the strabismus. The surgeon finds the position of *n* by carrying the flame of a candle along the perimeter, until, with his eye placed behind the flame, he finds that the corneal image of the flame occupies the centre of the pupil. The flame itself will then be at *n*, and the size of the squint-angle may be read off there. This gives the optical axis of the eye; but, to be strictly accurate, we must remember that the position of the visual axis is what is required, and that it lies a few degrees farther inwards, according to the size of the angle γ.

4. Tangent Strabismometer.—Maddox's tangent scale can be used to determine the angle of strabismus subjectively, by means of the diplopia if it be present, and also objectively, by the observation of the corneal reflex; in the latter respect it is only a modification of Priestley Smith's method. The scale has two sets of figures, large ones for a distance of five metres, and smaller ones for a distance of one metre. At the centre, or zero point, a candle is fixed, and also a string one metre long for adjusting the distance of the patient. The figures on one side of the zero are red, and on the other black.

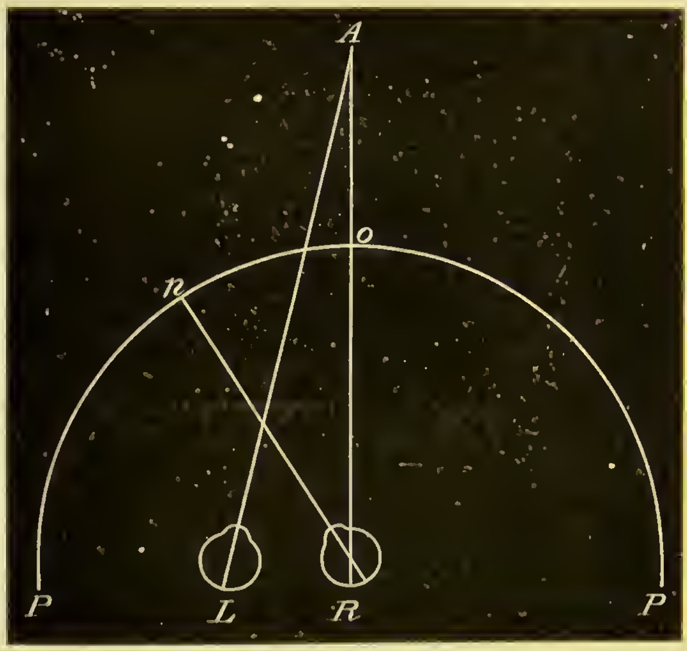

FIG. 203.

When diplopia is present, the patient is merely asked to indicate the figure opposite to which the false image of the candle appears.

In the objective method, the surgeon stands with his head below the zero of the scale, facing the patient; he then notes the eccentric position of the corneal reflex of the candle in the deviating eye; and, estimating the amount of the squint, directs the patient to look at this figure on the scale. If the estimate be correct, the reflection will be in its proper position; if it be not, the patient is directed to look at other figures higher or lower, as the case may be, until the position of the reflex is correct.

* *Mobility of the Eye in Convergent Concomitant Strabismus.*—This is often defective in the squinting eye, and sometimes also in the fixing eye. The method of measuring the excursions of the eyes has been described on p. 564. In strabismus we simply compare the outward mobility of the squinting eye with that of the good eye, to ascertain how much, if anything, the former lacks of its normal amount.

Before undertaking the treatment of a case of convergent stabismus, in addition to the points mentioned, the power of fixation of the squinting eye, the presence or absence of diplopia and the sense of fusion, the refraction, and the acuteness of vision, should all be ascertained. For testing the vision in very young children, Worth employs ivory balls of different sizes which he throws on the floor and asks the child to pick up.

Treatment of Concomitant Convergent Strabismus.—

(*a*) *Optical Treatment.* The total hypermetropia, and astigmatism if any, must be corrected, and the glasses must be worn constantly. In young children, atropine must be used to determine the refraction, and should be continued until the glasses are worn. Some surgeons order glasses for infants of twelve months or even less. The glasses frequently diminish or remove the strabismus while they are worn.

(*b*) *Orthoptic Treatment.*—To Javal is due the credit of devising this method. In England, of late, special attention has been given to it by Priestley Smith and by Worth. It consists in preventing the development of amblyopia, and in training the sense of fusion. To attain the first object, complete occlusion of the fixing eye for a certain period every day is necessary. Instillation of atropine in the fixing eye is also very serviceable, it frequently causes the strabismus to change over to this eye, especially when the originally squinting eye is used for near vision. When the vision is sufficiently improved, the training of the fusion sense should be undertaken. If diplopia be not present spontaneously it has to be developed ; and it is generally possible, when the sight in the squinting eye is not too defective, to give the patient diplopia—*i.e.*, to make him continuously conscious of the presence of the image belonging to the squinting eye. This may be done by means of exercises with a prism, base downwards, before the deviated eye, and a candle flame as visual object. The exercises are to be repeated daily, until diplopia without a prism is established.

Double vision having been established, we proceed to enable the patient to fuse the double images—*i.e.*, to obtain binocular vision—by exercises with the stereoscope, convenient forms of which are Priestley Smith's heteroscope, and Worth's amblyoscope, or a modification of the latter by Ramsay, in which the electric illumination of the images can be varied at will. The training of the fusion sense should be carried out during that time of life which is the period of normal development of this sense. After six years of age the results are unsatisfactory, and involve great trouble and patience.

As the patients are children, simple images, which require mere superposition without recognition of the third dimension, are generally sufficient at first ; later on, pictures of geometrical drawings involving perspective, can be used. Worth, however, believes that this treatment should be carried out by the surgeon, and that a child old enough to carry out stereoscope exercises himself is far past the age when the fusion sense might have been developed.

This method of treatment is useful, too, in completing the cures which have been commenced by operative measures.

(*c*) *Operative Treatment.*—According to some, operative procedures should not be undertaken, unless fusion training has failed, or is too slow and tedious, while the majority of surgeons still depend mainly on operative treatment, with or without the aid of the orthoptic method. Opinions differ as to the best age for operation, the majority of surgeons preferring to wait until the patients are over five or six years of age, while those who have studied the subject from the orthoptic side consider, that when an operation is indicated the earlier it is done the better.

The operations in use consist in tenotomy of one or both internal recti, or advancement of the external recti, or combinations of these, according to the degree of the strabismus and mobility of the eye.

Since concomitant strabismus is the result of a faulty innervation, and not due to a muscular defect, rules which will ensure in every case, with absolute certainty, the desired degree of operative effect cannot be laid down. The following will be found to answer in the majority of cases, and if the effect be now and then too great, it can be adjusted by bringing forward the internal rectus, or by setting back the external rectus, within a few days after the operation. When the fusion sense is very defective, it is safer to leave 2° or 3° of convergence; for the effect of the operation is apt to increase within a year, and, if absolute parallelism be present at first, divergence may ultimately supervene. The establishment of binocular vision, when it is possible, would do away with this remnant of strabismus; but under any circumstances this remnant does not detract from the cosmetic result.

If the vision of the squinting eye be fairly good, and the deviation amount to not more than 15° or 20°, and the power of the external rectus be sufficient, the correction can be effected by tenotomy of the internal rectus of the squinting eye. A strabismus of 20° will require the free separation of the delicate connections between the anterior surface of the tendon, or capsule of Tenon, and the conjunctiva as far back as the caruncle, in order that the tendon may be free to contract. For a deviation of 15° or less this separation should not be so free, or should be quite omitted; or, if a very slight effect be desired, it can be produced by drawing the conjunctival wound together, after an operation which has been confined strictly to the insertion of the tendon.

If the vision of the squinting eye be fairly good, and the power of the external rectus sufficient, and if the squint be more than 20°, it is advisable to divide the proceeding between the eyes—*e.g.*, if it be 30°, about 15° to 20° are corrected by tenotomy of the internal rectus of the squinting eye, and the remainder by tenotomy of the internal rectus of the fixing eye. If desired, the effect of the tenotomy in one or both eyes may be increased by a suture passed through a fold of conjunctiva at the outer side of the globe, and tied tightly. A double tenotomy is liable to damage the power of convergence, hence some prefer advancement of the external rectus of the squinting eye.

If, although the vision of the squinting eye be good, and the deviation not more than 20° or 25°, there be marked loss of power of the external rectus muscle, tenotomy of the internal rectus must be combined with advancement of the external rectus, of the squinting eye. But advancements in such cases as this must be very cautiously carried out, as an excessive effect may easily be produced. The external rectus should be but slightly brought forward.

If the deviation exceed 35°—even when there is good vision in the squinting eye, and no loss of power in the external rectus—tenotomy of the internal rectus of each eye is rarely sufficient, and as a rule advancement of the external rectus of the squinting eye must be combined with these measures.

With a deviation of 30° to 35°, and loss of power in the external rectus, the demand for advancement of the external rectus becomes more imperative. The correction of squints of 40° and more are, in every instance, to be effected by tenotomy with vigorous advancement in the squinting eye, and subsequent tenotomy of the internal rectus in the good eye.

In cases where the vision of the squinting eye is much reduced, the deviation great, and the insufficiency of the external rectus marked, the combined operation in one or both eyes is the proper proceeding.

* **Mode of Operating for Strabismus.** *Tenotomy.*—The instruments required for this operation are a spring-stop speculum, a small-toothed forceps, a blunt scissors somewhat curved on the flat, and two strabismus hooks (Fig. 204).

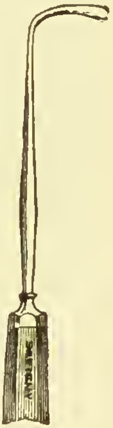

FIG. 204.

The eye having been thoroughly cocainised, the patient is placed on his back, the surgeon standing in front of him and on his left side if the left eye is to be operated on, or behind him if it be the right eye. The speculum is then applied, and the conjunctiva over the insertion of the tendon of the internal rectus is seized with the forceps, and incised with the scissors between the forceps and the eye. Into the opening thus made the points of the closed scissors are inserted, and, with a snipping action, a passage is made through the subconjunctival tissue —from the conjunctival aperture to the upper border of the tendon in case of the left eye, or to its lower border in the right eye. The scissors are now laid aside, but the conjunctiva is still held in the forceps; and, with the right hand, the point of the hook is passed through the opening and along the passage, until the edge of the tendon is reached. The point of the hook being kept in contact with the sclerotic, the instrument is then turned rapidly round and under the tendon, and is brought close up to the insertion of the latter into the sclerotic, care being taken that the whole breadth of the tendon lies on the hook. The forceps are now laid aside, and the hook carrying the tendon is transferred to the left hand. One blade of the scissors (held in the right hand) is now inserted between the globe and the tendon, and the latter is completely divided at its insertion. It is better to cut towards the handle of the hook than away from it, as there is then no tendency to push any fibres of the muscle off the hook. The second hook is then employed for searching, above and below, for any strands of the tendon which may be left undivided, the test for complete division being that the hook can be brought up without obstruction to the margin of the cornea. If the smallest segment of the tendon be left undivided, the result of the operation is apt to be unsatisfactory. Immediately after the operation, a marked diminution in the mobility of the eye inwards should be looked for; as this motion can now only take place by aid of any remaining connective tissue attachments of the muscle to the eyeball and capsule of Tenon. If this defect in motion be not present, or to only a slight degree in comparison with the supposed extent of operation, it may be concluded that the tendon is imperfectly divided, and a new search with the hook for undivided filaments must be made. To estimate this loss of motion it is necessary before the operation to note the degree of mobility of the eyeball inwards, and to compare it with the inward motion of the other eye.

The effect of the operation may be diminished, if found necessary, by drawing the edges of the conjunctival wound together with a suture, the tendon being thus prevented from uniting with the globe so far back. The more conjunctiva we include in the suture at each side of the wound the more will the effect of the tenotomy be reduced. This restricting suture should be applied, when the immediate result of the tenotomy is greater than expected or desired.

As the edges of the conjunctival wound cannot be accurately adjusted with sutures, none are applied for that purpose. They are used, as above, to diminish the operative effect; or, when an extensive loosening of the subconjunctival tissue has been performed, to prevent sinking of the caruncle.

The Subconjunctival Operation for Strabismus, is performed as follows:—A fold of conjunctiva is seized close to the lower margin of the insertion of the muscle, and incised with a blunt-pointed scissors, so as to expose the tendon. A strabismus hook is passed through the opening and under the tendon. The scissors is now inserted and opened slightly, one point being kept close to the hook, while the other is passed between the tendon and the conjunctiva, and the tendon is divided at its insertion. This method is very generally adopted by English surgeons, but that of von Græfe, previously described, is preferable, as it much more readily admits of modifications of the effect.

In von Arlt's Method, instead of a hook being passed under the tendon in the first instance, the latter is seized with the forceps with which, just previously, the conjunctiva had been raised. In other respects the proceeding is the same as von Græfe's, than which it is said to be less painful.

The immediate and ultimate effects of a tenotomy are by no means identical. Immediately after the operation the effect is very marked, owing to the loosening of the tendon from its insertion. In a few days, when the tendon becomes re-attached, the effect diminishes, and in the course of some weeks there is again an increase in the effect, and this increase continues for about a year, as above stated.

The ultimate result may, with tolerable certainty, be estimated immediately after the operation by testing the power of convergence. If the patient be directed to look with both eyes at the surgeon's finger held in the middle line, and it be approached to within 12 or 15 cm. of his nose, and if the convergence of the eyes can be maintained at that distance, the effect will not be too great. But if, at a distance of from 18 to 20 cm., the operated eye cease to converge, or begin to diverge, or if even at 12 cm. the convergence, although accomplished, cannot be maintained for more than a few moments, and that then the operated eye deviate outwards, ultimate divergence may be expected, even though the actual position of the visual axes be correct. A restricting suture must be applied in such cases.

Sometimes, although the patient converges up to 12 cm. satisfactorily, and maintains the convergence at that distance for some moments, the eye will then rotate inwards. In such cases there is apt to be a recurrence of the strabismus.

* *Advancement.*—In cases of convergent squint, in which it is desirable to combine advancement of the external rectus with tenotomy of the internal rectus, the latter is done first, as above described.

At the same sitting, an opening is then made in the conjunctiva immediately over the insertion of the external rectus, and as long as the breadth of the tendon. The band of conjunctiva between the opening and the cornea is separated up with the scissors from the sclerotic, for to it the tendon has to be fastened later on. A strabismus hook is now passed under the tendon, and brought well up to its insertion, care being taken that the whole width of the tendon is held on the hook. A needle carrying a fine silk suture is introduced from its upper margin between the tendon and sclerotic, and passed through the tendon at its middle line. In the same way another suture is passed behind the tendon from its lower margin, and through it, close to the first suture. Each of these sutures is knotted firmly on the tendon, a long end being left to each suture (Fig. 205). The tendon is separated off with the scissors from the sclerotic close to its insertion. The sutures are passed through the conjunctival flap in the direction of the muscle, and are respectively tied with their own ends. A greater or less effect is produced, according as the sutures are placed farther or nearer to the insertion of the tendon, and according as they are drawn more or less tightly.

Immediately after the combined operation is finished, there should be no divergence, nor should there be marked loss of motion of the eyeball inwards. In either case the effect is too great, and must at once be diminished by an adjustment of the advancing sutures, or a bringing forward of the internal rectus.

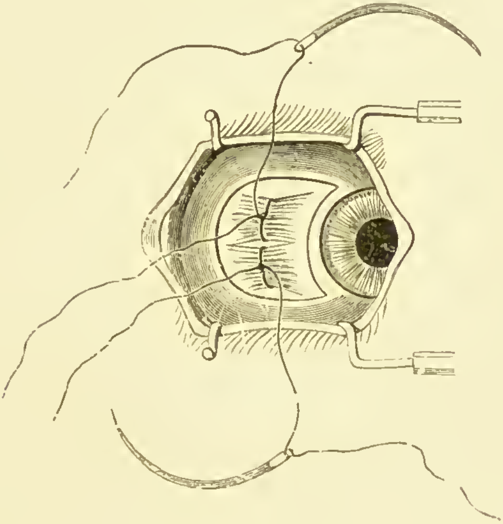

FIG. 205.

There are many modifications of the advancement operation. They consist in different methods of applying the sutures. A few operators merely make a tuck in the tendon without dividing it. In capsular advancement the muscle is advanced along with the capsule of Tenon, the tendon being folded over on itself when the sutures are tied.

Even if it be necessary to supplement the tenotomy (or combined operation) on the squinting eye by a tenotomy (or combined operation) on the fixing eye, both eyes should not be operated on at one and the same sitting. An interval of a fortnight or more should elapse, in order that the true effect of the first proceeding may be accurately gauged, and then the surgeon will be in a position to know how to regulate his operative measures for the other eye.

After a strabismus operation, a light dressing is applied, and is changed morning and evening for forty-eight hours, when, if no suture have been used, it may be discarded. If sutures have been employed, the dressing is retained until they come away.

* *Dangers of the Strabismus Operation.*—Severe inflammatory reaction after a strabismus operation is very rare, and should not occur, even after an advancement. Puncture of the sclerotic with the scissors while the tendon was being divided has occurred in the hands of some operators; but except with a sharp-pointed scissors, or want of care, this cannot occur. It is also stated, that eyes have been lost after squint operations through orbital cellulitis, which, beyond doubt, must have been brought about by the introduction of septic matter upon the instruments.

Occasionally, a small arterial branch may be divided during the operation, and this, bleeding into the capsule of Tenon, may cause rather alarming exophthalmos. The protrusion goes back in a few days with use of a pressure bandage.

Sinking of the caruncle, some months after the tenotomy, when it does rarely occur, can be remedied in the following way :—The conjunctiva is divided vertically about 6 mm. from the caruncle. The inner lip of the wound is raised, a scissors curved on the flat passed in, and the subconjunctival tissue as far as under the sunken caruncle separated. The subconjunctival tissue under the outer lip of the wound, and as far as the corneal margin, is loosened in the same way, and the two flaps are brought together with a suture, which includes a sufficiency of conjunctiva to draw the caruncle well forwards.

Treatment subsequent to Operation.—It is generally necessary for the patient to wear the correcting spectacles for his hypermetropia either constantly or for near vision only, according as the result of the operative measures makes it more or less desirable to suspend the accommodation. After some months, it is usually possible to leave off the spectacles, except for near vision.

A cure of the strabismus, in the sense of removal of the deformity, can be attained by operation, and by itself affords ample indication for the operation. But a cure, in the true sense of the term, involves restoration of binocular vision, and this is very rarely obtained by operative measures alone. To this end the operation must be followed up by orthoptic treatment as already described (p. 619).

Divergent Concomitant Strabismus.—This form of strabismus is not so common as convergent squint. Two-thirds of the cases are due to myopia, which is generally more than 5 or 6D. It also occurs apart from myopia, and is then most frequently neuropathic.

In myopia, two causes contribute to weaken the power of convergence for near vision. In the first place, little or no accommodation is required, and hence a tendency exists to relax the convergence. Furthermore, when the working distance is too close to the eyes, the increased effort of convergence which is necessary cannot always be maintained. At first the weakness of convergence manifests itself only in near vision (insufficiency of convergence), but later on it results in absolute divergence for distance. Myopic divergent squint makes its appearance later in life than convergent squint, and the fusion sense is better developed than in the latter. Neuropathic divergent squint on the other hand is chiefly congenital, and the fusion sense is defective or absent. The degree of divergence is very liable to vary from time to time in these cases.

Treatment.—The correction of the myopia, by establishing the proper relations between accommodation and convergence, will cure the divergence in recent cases (see Insufficiency of Convergence, p. 638). The glasses should be worn constantly. In other cases, advancement of one or both internal recti should be performed, with tenotomy of the external recti if the power of abduction be greater than normal.

Non-paralytic divergent strabismus also occurs in blind eyes, and in high myopia. In the high degrees of myopia the movements of the eyes are more or less impaired, owing to their egg-shaped elongation. When the vision of one eye becomes defective, or when it becomes blind, there is always a tendency to divergence, unless the other eye be hypermetropic. If one eye be myopic and the other emmetropic, the myopic eye is often used for near vision, and then the other eye diverges, whereas the emmetropic eye serves for distance, and the myopic eye may then be divergent.

*** Latent Deviations, or Muscular Insufficiencies (Heterophoria).**—When the orbital muscles are in a state of normal equilibrium, or orthophoria, and the eyes are fixing an object either distant or near, if one eye be covered, and thus excluded from the act of vision, it nevertheless continues to maintain its direction, and no deviation of the eye takes place behind the screen, or hand. But if the muscular balance be imperfect (heterophoria), there is a tendency for the eyes to deviate from the correct position, which tendency, however, under ordinary conditions, is kept in check by the desire for single vision. The deviation is suppressed by a special muscular effort, and only becomes manifest under artificial conditions; namely, when the vision of the two eyes is dissociated, by such measures as render binocular vision difficult or impossible. This form of deviation is therefore said to be latent, and is sometimes known as suppressed squint.

Latent deviations, due to disturbance of the relation between accommodation and convergence, occurring in errors of refraction (such as latent convergence with hypermetropia), are not to be regarded as heterophorias.

If the fusion sense become impaired—by disease of one eye for example—a latent deviation may become manifest and may lead to true strabismus.

Latent deviations may be in the direction of convergence (Esophoria), or divergence (Exophoria), or the eyes may tend to turn in opposite directions vertically, one eye being higher than the other (Hyperphoria), and the condition is called right or left hyperphoria, according to the eye which is the higher.

The muscular effort necessary to keep the tendency to deviation in control sometimes leads to the development of asthenopic symptoms (muscular asthenopia). Special attention has been paid to this form of 'eye strain' in the United States, where it has been held accountable for nervous affections, such as neurasthenia, hysteria, migraine, chorea, and epilepsy.

This view, however, is generally regarded as somewhat exaggerated. It is more probable that heterophoria merely acts as an additional exciting cause of nervous attacks, in those who are already subject to the conditions mentioned. Defects in the muscular balance are not more common in neuropathic than in healthy individuals, who do not suffer from asthenopia; and these defects may be present in the former, without giving rise to asthenopia.[1]

* *Tests for Latent Deviations.*—The best test object for distance (six metres) is a candle flame or frosted electric lamp, and for near vision a black dot or line.

1. *Test by Exclusion of One Eye.*—While the eyes fix the test object, one eye is covered by the surgeon's hand, and its position, as shown by the corneal reflex for instance, is

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[1] Bielschowsky, *Bericht. d. Ophth. Gesellsch.*, Heidelberg, 1905 p. 25.

observed immediately on withdrawing the hand, as also any movement which the eye may make to right itself. The latter movement indicates a deviation in the opposite direction—*e.g.*, if the eye move inwards on being uncovered, it must have been deviated outwards when covered. Both eyes must be examined alternately. When a heterophoria is present, it generally exists in both eyes, and is of the same kind. In hyperphoria (vertical deviation), the eye which is higher will rotate downwards, and its fellow will make a movement upwards; for example, in left hyperphoria the left eye will deviate upwards when covered, and will adjust itself by a downward movement when uncovered; the right eye, on the other hand, when screened will deviate downwards, and will rotate upwards on re-exposure. This test, however, is by no means so delicate as the following subjective tests, which depend on the production of diplopia.

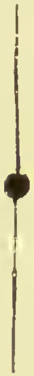
FIG. 206.

FIG. 208.

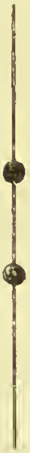
FIG. 207

2. *Tests with Prisms.*—(*a*) This test was first used by von Græfe for the examination of insufficiency of the internal recti. A prism is placed vertically before one eye, of such a strength that it cannot be overcome by the muscles; one of 10° is sufficient. A dot with a fine line drawn vertically through it (Fig. 206) on a sheet of white paper is given to the patient to look at, at his usual reading distance. If the prism be placed with its base downwards before the right eye, this, in the normal condition, both eyes fixing, would produce a double image of the dot and line, placed of course vertically, one over the other, and as the images of the

lines overlap, the figure would seem to be a line with two dots, the upper dot being the image belonging to the right eye (Fig. 207). In insufficiency of the interni (ex ophoria), the image of the right eye would not only be higher than that of the left, but it would also stand to the left (crossed double images) more or less ; so that here the picture is that of two lines, each with a dot, the upper line and dot standing to the left side (Fig. 208). This crossed diplopia indicates divergence. In this case the artificially produced vertical diplopia renders the latent deviation manifest, and a lateral diplopia is superadded.

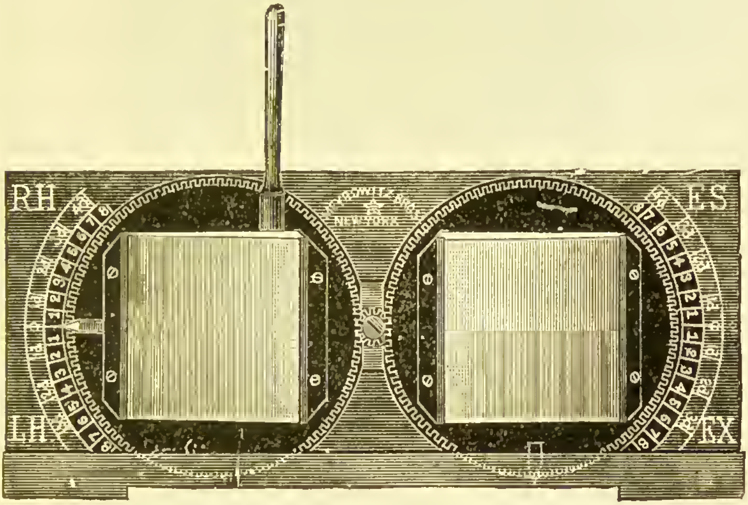

FIG. 209.—The prisms of Stevens' phorometer.

In order to test for vertical deviations (hyperphoria), the prisms must be placed horizontally, and with their bases inwards ; because the external being much weaker than the internal recti, prisms of lower degrees can be used ; but for this purpose the rod test described below is better.

(*b*) Stevens' phorometer (Fig. 209) is a convenient instrument for applying the prism tests. The prisms can be placed either vertically or horizontally by the lever, and the degree of heterophoria can be measured by a rotation of the prisms, the amount of the deviation being indicated on the scales to the right and left.

(*c*) Maddox's Double Prism is also useful. It is composed of two prisms, base to base, and is easily adjusted.

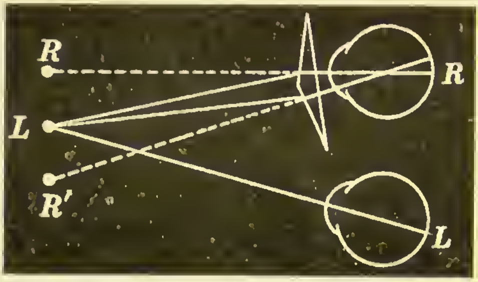

FIG. 210.

When placed vertically before, say, the right eye, with the line of junction of the prisms opposite the pupil, this eye sees two images of the spot, one vertically over the other, and, if the muscular equilibrium be normal, the spot seen by the left eye will appear to be in a line with the other two, and midway between them (Fig. 210). If a horizontal line be used as the test object, the different forms of heterophoria can be diagnosed by the position of the central line seen by the left eye, with reference to the two lines seen by the right—*e.g.*, Fig. 211 indicates normal equilibrium, and Fig. 212 left hyperphoria and esophoria.

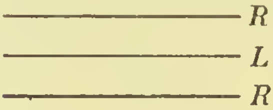

FIG. 211.—Normal equilibrium.

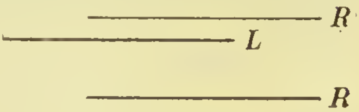

FIG. 212.—Left hyperphoria and esophoria.

3. Maddox's Rod Test.—This is probably the best

test. The apparent lengthening of a flame into a line of light, when looked at through a strong cylinder, is utilised to make the two images so dissimilar, that no desire to unite them remains. The chief advantage of this principle is that slight malpositions do not, as with prisms, vitiate the result materially. The instrument consists of a number of parallel glass rods (Fig. 213) usually coloured red, which thus produce a red line of light, at right angles to the axis of the rods, when placed before one of the eyes, the other eye seeing the light or flame naturally. When the red line passes through the flame there is orthophoria (Figs. 214 and 215).

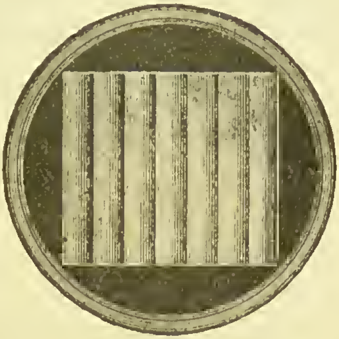

FIG. 213.—Maddox's Rods.

The line of light must be vertical, and therefore the rod must be placed horizontally for horizontal deviations (Fig. 214), and the opposite way for vertical deviations (Fig. 215). The defect is measured by the deviating angle of the prism, which is found to bring the light and line together, or, preferably, by a tangent scale, placed with its zero just behind

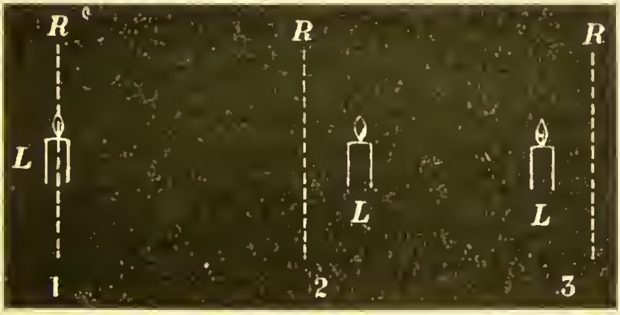

FIG. 214.—1. Orthophoria. 2. Exophoria or latent divergence. 3. Esophoria or latent convergence.

the flame, so that the figure crossed by the line of light gives the deviation in degrees. For vertical diplopia the scale should be vertical, and for horizontal diplopia, horizontal. In either case the axis of the cylinder should be parallel to the scale. When the cylinder is vertical, it should be shaded from the light of the window. By placing the patient's head in different positions, the diplopia can be measured in all parts of the motor field. Vertical and horizontal scales should, for this purpose, be fixed on the wall, with their zero points coinciding at the position of the flame. This test is most useful for distant vision (6 metres). For near vision the double prism is better.

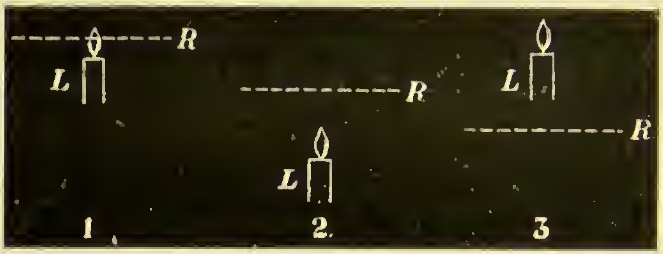

FIG. 215.—1. Orthophoria. 2. Left hyperphoria. 3. Right hyperphoria.

In order to obtain accurate results when testing the muscular balance, any error of refraction must be corrected.

* *Symptoms of Heterophoria.*—Great difference of opinion exists as to the frequency with which heterophoria gives rise to asthenopia. In the United States, it is said to be very common. There is no doubt that heterophoria may be present without causing any inconvenience. Hyperphoria is the most troublesome form, and then esophoria, while exophoria, unless combined with a diminished amplitude of convergence, causes little or no annoyance. The symptoms are: headache and pains in the eyes—especially towards the end of the day, or following on long-continued close observation—giddiness, and conjunctival hyperæmia. Narrowing

of the palpebral fissure sometimes occurs in hyperphoria, in the eye which deviates upwards.

Treatment.—This will depend, not merely on the degree of the heterophoria, but also on the strength of the muscles, as measured by their power of overcoming the diplopia produced by prisms. Whether the heterophoria be present in near, or distant vision, or in both must also be considered. In near vision at a distance of 12″ an exophoria of 2° to 4° is physiological.

The treatment consists in the wearing of prisms with the base in the direction of the muscle to be relieved (see p. 6), exercises with prisms, or operation. The first two will suffice in moderate degrees of the defect; but it may be mentioned that the value of exercises with prisms is doubted by some surgeons. When only a prism of low degree is required, the desired effect may be accomplished by decentration of the lenses (see p. 18), correcting the error of refraction, if there be one. In the higher degrees operation may be necessary, advancement of a muscle being preferred to tenotomy of the antagonist in case of defective power in the muscle. In Europe, graduated tenotomies, by which is meant partial division of the fibres of the tendon, are not regarded with favour.

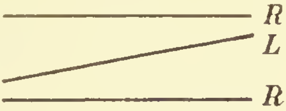

FIG. 216.

* *Cyclophoria* (*Latent Torsion*).—This consists in a tendency to abnormal rotation round the antero-posterior axis, so that the vertical meridians of the eyes are no longer parallel. The subject is not, as yet, well understood. A certain amount of torsion appears to occur physiologically in near vision. Latent torsion can be detected with the double prism, a horizontal line being used as the test object. If it be present, the line seen by the naked eye, between the double image, will not be parallel to the double lines seen by the eye clad with the prism. Fig. 216 indicates an inclination of the upper

ends of the vertical meridians towards one another. The opposite is, however, the more common condition. Maddox's rod and Stevens' clinoscope are also used for testing cyclophoria.

According to Savage, in astigmatism with oblique axes, torsion is necessary to make the vertical meridians coincide with the nearest meridian of the astigmatism ; and he believes that this accounts for the fact, that some astigmatic people are more comfortable without correction of their astigmatism, being unable to abandon the torsion to which they had become habituated.

Insufficiency of Convergence.—This has to a great extent been confused with exophoria (latent divergence) for near vision ; indeed, von Græfe's test is really more a test for the exophoria or esophoria existing in near vision, than for insufficiency of convergence. The two conditions may coexist, but one does not involve the other. Either may be present alone ; furthermore a latent convergence (esophoria) may in some cases exist along with insufficiency of convergence. The essential point in the diagnosis of the latter condition is the presence of a diminution of the amplitude of convergence (see p. 30) as measured by gradually approaching to the eyes, in the median line, a series of parallel fine lines, or an illuminated line or point, until one eye is seen to diverge, or until the patient gets homonymous diplopia. The test should be made on several different occasions, as results are liable to vary with the state of health or available energy of the patient.

Causes.—Insufficiency of convergance usually depends on defective innervation, due to a central cause, which may be organic, as in locomotor ataxy, or more commonly functional, as in hysteria, neurasthenia, anæmia, and exophthalmic goitre (partly). Other causes are myopia (see Divergent Strabismus, p. 629), and perhaps sometimes anatomical defects in the internal recti.

Symptoms.—Patients complain of pains in the head and eyes, and fatigue after reading, sewing, etc., for any length of time; they feel inclined to hold the book or work farther from them, and they sometimes get relief by closing one eye.

Treatment.—In the neuropathic and debilitated, the general health requires attention both mentally and physically, and out-of-door exercise, with mental quiet, should be recommended. With regard to local treatment, exercises in convergence, with or without the aid of the stereoscope, should first be tried, any error of refraction being of course corrected. A full correction of myopia, and an under-correction of hypermetropia may render assistance, by making demands on the accommodation, and thus indirectly on the convergence. If exercises prove useless, prisms with bases inwards may give relief, or, if glasses be worn, they can be decentred (p. 18).

Should these methods not succeed, tenotomy of the external rectus may be performed, if the negative portion of convergence, as well as the outward mobility of the eyes, be good; otherwise advancement of the internal rectus is the better operation. Landolt prefers advancement, in most cases, as he believes that by means of it, while the positive convergence is considerably increased, there is no loss whatever in the negative portion, whereas tenotomy leaves a permanent diminution in the latter.

NYSTAGMUS.

This term indicates an involuntary rhythmical oscillation of the eyeballs laterally (the most common form), vertically, or with a rotary motion (caused by the oblique muscles). It is usually constant, but may increase in certain positions of the eyes and diminish in others. Sometimes it is accompanied by oscillation of the head.

It is most commonly found along with congenitally defective vision—microphthalmos, coloboma of the chorioid, albinism, etc.—or in those whose vision suffered in infancy, *e.g.*, leucoma of the cornea, anterior polar cataract caused by ophthalmia neonatorum, etc.; but it may be acquired, and is often seen in those employed in coal-mines. It occurs in about one-half the cases of disseminated sclerosis.[1] In rare instances it can be produced voluntarily; in one case of the kind that we have observed, the individual brought it on by converging as much as possible.

Temporary nystagmus sometimes occurs when syringing an ear, and in some cases of ear disease, due to irritation of the semicircular canals.

In the congenital cases, it is probable that the absence of the stimulus, which accurate retinal impressions afford, interferes with the functional development of the co-ordinating centres for the orbital muscles. In coal-mines, the very defective light, and the blackness of the surroundings, deprive the miners of any defined retinal impression, and hence their co-ordinating centres are apt to become deranged. But, as it is chiefly those who work in one constrained position on their sides, with eyes directed obliquely upwards, who become affected, it seems probable that this unnatural, and long-continued direction of the eyeballs, is an important factor in the production of the affection; indeed, it may be to a great extent a professional cramp, like writer's cramp. In fact, a case of acquired nystagmus in a compositor, due to working in a strained position, has been recorded by Snell.

Those patients, in whom nystagmus is due to a congenital defect of vision, do not complain of oscillation of the objects they look at; but individuals, who become affected with it in later life, are much troubled with that symptom, especially at the onset.

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[1] According to Gowers (*Diseases of the Nervous System*, vol. i., 2nd Ed.), nystagmus occurs often in ataxic paraplegia, primary spastic paraplegia, and hereditary ataxia, sometimes in severe multiple neuritis and syringomyelia, but rarely in progressive muscular atrophy.

Treatment.—In congenital cases, which admit of improvement of vision, a cure, partial or complete, is sometimes brought about when the vision improves. If strabismus be present it should be cured, after which a diminution in the oscillations may result. In miner's nystagmus, the all-important measure is a permanent relinquishment of mine work; and this is frequently followed by satisfactory results.

CHAPTER XIX.

DISEASES OF THE ORBIT.

Orbital Cellulitis.—*The Symptoms* of this affection are: erysipelatous swelling of the lids, especially of the upper lid; serous chemosis; pain in the orbit, increased on pressure of the eyeball backwards; violent facial neuralgia; exophthalmos, with impairment of the motions of the eye in every direction; and high fever, sometimes with headache and vomiting.

Vision is not generally affected, but sometimes it is so from optic neuritis, and then, too, mydriasis is seen. The cornea is often completely or partially anæsthetic.

The surgeon, by pressing the tip of his fourth finger between the eyeball and the margin of the orbit, may feel a more or less resistant tumour. This gradually increases in some one direction, the integument in that position becomes redder, fluctuation becomes pronounced, and the abscess finally opens through the skin, or into the conjunctival sac, the pointing being usually at the upper and inner angle of the orbit. Restoration to the normal state, as a rule, comes about; but in some cases complete atrophy of the optic nerve supervenes. Other cases, however, recover without the formation of pus; while again, even meningitis or cerebral abscess may ensue.

In panophthalmitis (p. 370), as in orbital cellulitis, exophthalmos, loss of movement, swelling of the lids and chemosis also occur, but in panophthalmitis these symptoms are preceded, and also accompanied, by purulent iridocyclitis, or suppuration of the cornea.

Causes.—(1) Idiopathic (*e.g.*, cold); (2) traumatic (perforating injuries, foreign bodies); (3) extension of inflammation from surrounding parts (erysipelas, diseased tooth, ethmoidal cells); (4) metastasis (pyæmia, metria); (5) sequelæ of fevers (scarlatina, typhoid, purulent meningitis, influenza).

Treatment.—Locally, poultices or warm fomentations; and, when pus has formed, its earliest possible evacuation —by preference from the conjunctival sac. The general constitutional treatment suitable to each case need not be discussed here.

* **Tenonitis,** or **Inflammation of the Capsule of Tenon,** is an uncommon affection, the symptoms of which are those of a moderate cellulitis of the anterior part of the orbit. As in orbital cellulitis, the lids are red and swollen, there is slight exophthalmos, with restricted mobility of the eye, and chemosis, but no conjunctival discharge. The diagnosis (as distinguished from cellulitis) rests on the slight degree of exophthalmos, as compared with the great loss of mobility, and relatively well-marked chemosis. In the early stage, before the inflammatory symptoms have declared themselves, the patient complains of periorbital neuralgia, followed by a sense of pressure in the eye, and great pain on attempting to move it, so much so that the eyes are kept closed and immovable (Panas). One or both eyes may be affected, and relapses are common. Vision is not affected, and febrile symptoms are much milder than in cellulitis. The prognosis is good, recovery taking place in about a week. Sometimes suppuration occurs, and a small subconjunctival abscess forms, which generally opens upwards and inwards. In addition to the serous and purulent varieties, a chronic plastic form of the disease has also been met with.

Causes.—Chronic rheumatism (sometimes with effusion into a joint), and influenza. The suppurative form may be traumatic, or may follow measles or scarlatina.

Treatment.—Warm fomentations, and a light bandage, with salicylate of soda, or quinine internally. Panas speaks highly of antipyrin.

Thrombosis of the Cavernous Sinus gives rise to symptoms which may be mistaken for those of an orbital process. It frequently spreads to the other side, and is accompanied by cerebral symptoms. The affection is described at p. 600.

Periostitis of the Orbit.—Acute periostitis of the orbit has many symptoms in common with phlegmonous inflammation of the orbital connective tissue, which generally accompanies it; but may usually be distinguished from the latter, inflammation occurring independently, by the fact that, in it, pressure on the orbital margin is painful. The absence of this tenderness, however, is not always conclusive of the absence of periostitis, especially when the latter is restricted to the deep parts of the orbit. In periostitis, the eyelids are not usually so swollen as in inflammation of the orbital tissues. Suppuration may take place, necrosis in consequence of detachment of the periosteum may come on, and communications with the neighbouring cavities may be formed.

In secondary syphilis, or in later stages of the disease, a syphilitic gumma of the orbital wall may form. This is accompanied by violent frontal neuralgia or headache, increasing at night. Proptosis (πρό, *forwards*; πτῶσις, *falling*), or protrusion of the eyeball occurs, with marked loss of motion in the eyeball in one or more directions. This early loss of motion is a very characteristic symptom, and serves to assist in the diagnosis between this affection and other orbital tumours. It is probably due to an extension of the inflammation to the connective tissue of the orbit, and to the muscles themselves.

Symptoms very suggestive of gummatous periostitis of the orbit are:—A rapidly increasing proptosis, with displacement of the globe downwards and forwards, and much loss of motion of the eye, while on palpation the sensation is given to the finger of a tumour in the roof of the orbit, where gummata most commonly are situated. Also, thickening of the upper margin of the orbit, with pain on pressure of the roof of the orbit, and radiating peri-orbital pain at night.

Again, periostitis of a chronic form, and without tendency to suppuration, occurs most commonly in persons with a constitutional rheumatic tendency. It is accompanied by pain in and about the orbit, and there is increased tenderness on pressure of the eyeball backwards. Exophthalmos, and all other outward signs, are here usually wanting.

The Prognosis depends much on the seat of the inflammation. If this be in the deep parts of the orbit, thickening of the periosteum may cause permanent protrusion of the eyeball; extension of the inflammation to the optic nerve may result in optic atrophy; the orbital muscles, or the nerves which supply them, may be implicated, with consequent paralysis; or, finally, the inflammation of the periosteum may strike into the meninges of the brain. When the inflammation is near the margin of the orbit, early evacuation of pus, if it have formed, reduces the process within safe bounds; and this position is one of less danger in respect of its surroundings, than if the process be deep in the orbit.

Causes.—Periostitis of the orbit may be caused by blows or other traumata, by extension from neighbouring cavities, by syphilis, or by rheumatism.

Treatment.—Warm fomentations. Exit given to pus, if possible. Constitutional treatment. Incision along the orbital margin, and separation of the periosteum, with drainage, may shorten the process, if the foregoing measures do not give relief.

Caries of the Orbit is very frequently the result of periostitis, but often commences in the bone, and in either case is usually due to tubercular disease. It is also seen in very late syphilis. A trauma is sometimes the immediate cause of its onset.

Caries may attack any part of the orbital walls, its favourite seats being the margin above and to the outside, or below and to the outside. When it is seated deeply in the orbit, it often causes exophthalmos and pain. At the margin of the orbit it produces œdema and swelling of the eyelids, with conjunctivitis; suppuration comes on, and the abscess finally opens through the integument or conjunctiva. A fistula is apt to remain for a length of time, and, the skin being drawn into this, ectropion of the lid is produced. If a portion of dead bone come away, the resulting cicatrix is liable to maintain the ectropion (p. 316).

Treatment.—The evacuation of purulent collections at the earliest possible moment—if deep in the orbit, by the careful introduction of a long bistouri—the insertion of a drainage-tube, and the regular washing out of the cavity with antiseptic solutions, until no more rough or bare bone can be felt with the probe. If the case be very tedious, Krönlein's operation may permit of the removal of sequestra with greater ease and security.

Injuries of the Orbit.—Wounds of the soft parts in the supraorbital region, involving the supraorbital nerve, are held by some to be capable of producing a reflex amaurosis (chap. xx. part v.), and many such cases have been recorded under the name of supraorbital amaurosis. By the light of modern physiology and ophthalmology it is not probable that any such reflex could take place. It seems more likely that the blindness in the cases recorded was brought about in some other way—*e.g.*, injury to the optic nerve in the optic foramen by the concussion, or by a fracture of the margin of the foramen, orbital periostitis, concomitant injury to the eyeball itself, facial erysipelas, intracranial lesions, and so on

It may be, however, that a functional amblyopia, or amaurosis, similar to that occasionally seen, after long-continued blepharospasm (p. 202), has sometimes been present.

Perforating injuries, more especially of the roof of the orbit through the eyelids, by prods of walking-canes, etc., and the lodgment of foreign bodies in the orbit are serious accidents. They are liable to be followed by phlegmonous inflammation; or, if a pointed weapon (stick, sword-cane, etc.) has been pushed into the orbit with some force, it may pass through the bony wall and perforate the brain, with fatal result.

It is remarkable what large foreign bodies may be concealed in the orbit. We have removed large pieces of wood, which had lain in the orbit, in one case for weeks, in another for several months without inflammatory symptoms. In the first there was even no exophthalmos.

Hæmorrhage into the Orbit may occur from injury, and may cause exophthalmos, or atrophy of the optic nerve from pressure. Such orbital hæmorrhages are sometimes met with at birth, as the result of complicated labour, especially when the forceps has been applied.

Hæmorrhage in the Eyelids, with ecchymosis of the conjunctiva, commonly known as a black eye, is usually the result of blows with large blunt objects, such as a fist. The object which causes the injury is arrested by the margin of the orbit, against which the tissues are bruised, while the eye usually escapes. On the other hand, when the object is small or sharp, it enters the orbit, and injures the eyeball, and there is less tendency to external bruising.

Deep Fractures of the Orbit, in the neighbourhood of the optic foramen, may cause atrophy of the optic nerve without any other symptom.

Emphysema of the orbit, or of the lids, or of both, sometimes occurs from injury of the ethmoid, or rupture of the mucous membrane of the lacrimal duct. The emphysema only develops when a strong expiratory effort is made, such as blowing the nose, after the injury. It also occurs in perforation of the ethmoid from disease, and even, rarely, without previous disease.

Treatment.—Foreign bodies should be removed by dilatation of their wounds of entrance, or by the formation of a new passage through the conjunctival fornix—and great care should be taken to prevent the onset of inflammation, or to keep it within safe bounds. A pressure bandage, and the exercise of caution when blowing the nose for a little while, is all that is required in emphysema.

* **Enophthalmos**, or sinking of the eye back into the orbit, occurs to a certain extent in extreme emaciation, in Asiatic cholera, in paralysis of the sympathetic, and in facial hemiatrophy. But it has been observed to an extreme degree as a result of injury; and in these cases atrophy, or cicatricial contraction of the retrobulbar cellular tissue, and paralysis of Müller's muscle, from injury of the sympathetic nerve, have been held accountable for the condition. In some cases, it is due to fracture or depression of a portion of the orbital wall.

Enophthalmos is sometimes congenital; it is also present, occasionally, in intermittent exophthalmos (p. 657), when the patient is in the erect position, and after removal of retrobulbar tumours.

***Orbital Tumours.**—In the *Diagnosis of an Orbital Tumour* three questions present themselves:—First, Is a tumour of the orbit present? Secondly, Is the new growth confined to the orbit, or does it extend to neighbouring cavities? and thirdly, Of what kind is the new growth? The diagnosis as regards any of these points does not often occasion much difficulty in advanced stages of the disease, especially where the growth occupies the anterior part of the orbit, or protrudes from it. It is rather in the early and middle stages that difficulties in diagnosis are apt to present themselves, and attention will here be mainly directed to those stages.

Exophthalmos (or proptosis) is, of the signs by which the presence of a tumour is diagnosed in its early stages, by far the most important, because it is the most constant. In the earliest stages of a growth which commences in the deepest part of the orbit there may be, it is true, no exophthalmos, while other symptoms—defects of sight, pain, loss of motion—may already be present; but when the growth attains to certain dimensions, or if in the anterior part of the orbit there be even a small tumour, the eyeball must be pushed out of its place.

An important diagnostic point in connection with the exophthalmos caused by a tumour is that its direction is almost always oblique and not straight forwards;—unless it be within the muscular cone—for orbital tumours commonly tend to develop more along some one wall of the orbit than along the others, and hence the eyeball becomes pushed towards the opposite side as well as forwards. In cellulitis, œdema of the orbital tissues, Graves' disease, and paralytic proptosis, the exophthalmos has a direction straight forwards. Tumours growing from the apex of the orbit may, in their early stages, cause no obliquity of direction in the displacement of the globe, and some tumours do not do so even in an advanced stage of their growth; but these cases are exceptional. Tumours, too, situated altogether within the muscular cone, of which the most common are tumours of the optic nerve, need not cause any lateral displacement of the globe.

Again, the exophthalmos caused by an orbital tumour usually increases in degree slowly and gradually, differing in this respect from exophthalmos due to most of the other causes, in which either a sudden or a rapid development of the proptosis is the rule.

While tumours are sometimes present in both orbits, especially lymphoma or lympho-sarcoma, yet it is infinitely more common for one orbit alone to be diseased; and hence monolateral exophthalmos is suggestive of orbital tumour.

Palpation in the Orbit often provides a valuable sign, should the new growth have come within reach in the anterior part of the cavity. In many cases, indeed, there is no difficulty whatever in recognising the presence of an orbital tumour by this means, the sensation obtainable by the tip of the surgeon's finger pressed into the orbit being very definite ; in some the tumour can only be felt when the patient is anæsthetised ; but in other cases the evidence is not so clear, and a reasonable doubt may exist as to whether any abnormal resistance is met with. By palpation we may gain some knowledge of the position, extent, shape, and consistence of the tumour, and whether it be adherent, either to the walls of the orbit or to the eyeball. It is important, when practicable, to compare the result of examination of the diseased orbit with the condition of the sound orbit ; and this can be done to greater advantage, if palpation of the orbits be performed simultaneously with a finger of each hand.

The Röntgen Rays have been successfully employed in some cases for the diagnosis of retro-bulbar growths.

Derangements of Vision are often, but by no means always, present in the early and middle stages of the growth of an orbital tumour. Their occurrence depends frequently on the rapidity of the growth of the tumour, rather than upon its size. In an early stage of a rapidly increasing tumour, the sudden stretching of, and pressure on, the optic nerve may produce absolute blindness ; while in another case, with an equal degree of proptosis, but which has been brought on by a slowly growing tumour, vision may be unaffected, by reason of the optic nerve becoming gradually accustomed to the change. Yet slowly growing tumours, which spring from the optic nerve or its neighbourhood, or from the deepest part of the orbit, are competent, by direct pressure on, or by implication of the optic nerve, to cause serious loss of sight, even in an early stage, and with but little exophthalmos. Optic neuritis, and, later on, optic atrophy, are occasionally discovered with the ophthalmoscope. Diplopia is often present when the globe is at first displaced, but disappears when tha exophthalmos becomes extreme or the vision defective.

Pain is a symptom sometimes, but by no means always, present in cases of orbital tumours. It is especially liable to be complained of when the growth is increasing rapidly in size, even though it may not have attained to great dimensions. The pain is then often of a neuralgic kind, and very severe, from the unaccustomed pressure on branches of the fifth nerve in the orbit.

Loss of Power of Motion of the Eyeball is a very common symptom in cases of orbital tumours. It is caused in some cases by the mechanical obstruction offered by the tumour, as a result of which motion of the eyeball becomes defective towards the side of the orbit on which the new growth is situated. In other cases the loss of motion is caused by stretching of the muscles from the exophthalmos, or by implication of them in the new growth, or by atrophy of their tissue, or by paralysis of the orbital nerves from pressure.

When there is little or no loss of motion, while the proptosis is marked, the conclusion may be drawn that the tumour lies within the muscular cone.

In every case the history, the rapidity of growth, the age and general condition of the patient are important items for consideration.

Diagnosis of the Nature of an Orbital Tumour.—As regards the nature of the growth which may be present, it must be admitted that in many instances, in the early stages of a deeply seated tumour, we have to rest content with an indefinite or provisional diagnosis, unless an exploratory operation, with puncture or harpooning of the mass, is practicable.

Primary tumours of the orbit may be conveniently described under the following heads :—Cysts, solid tumours, pulsating exophthalmos, symmetrical tumours, tumours of the optic nerve, and tumours of the lacrimal gland.

Orbital Cysts are usually congenital (Dermoids, Encephalocele, Serous) but may be acquired (Hydatid, Cysticercus).

Dermoid Cysts are those most frequently found. Although congenital, they do not often grow to any size until the age of puberty or later, and may then for the first time give rise to troublesome symptoms. They grow slowly, and finally reach very considerable size, and then bulge out between the eyeball and margin of the orbit. Pressure upon this protruding part causes it to diminish, while the exophthalmos is at the same time increased, and distinct fluctuation in the protruding part can be felt. The growth of the cyst is unaccompanied by pain or other inconvenience. It may adhere to the periosteum and cause bony irregularities, or even perforate the roof of the orbit. The contents are generally either serous or honey-like, and occasionally hairs and other epidermic formations have been found in them.

Hernia Cerebri, either in the form of meningocele or of encephalocele, may invade the orbit. Its most common situation is the upper and inner angle of the orbit, to which it gains access through the suture between the frontal and ethmoid bones. It appears as a fluctuating, often transparent, pulsating congenital tumour. Sometimes the opening in the bones can be felt around its base. Pressure upon it causes it to disappear, but gives rise, at the same time, to symptoms of cerebral irritation, or pressure.

A congenital tumour in the upper inner angle of the orbit must always be regarded with suspicion, lest it be a cerebral hernia, even though it do not pulsate, or on pressure cause cerebral symptoms. In the large cerebral herniæ, death in the first few days of life is the rule.

Cysts with Anophthalmos.—These appear as serous cysts, which project into the lower lid, giving it a slightly bluish tinge. They are associated with so-called anophthalmos (Fig. 217), in which, in spite of the name, a small or rudimentary eyeball is always found. The cavity of the cyst frequently communicates with the interior of the eye and contains retina more or less altered and thrown into folds. These cases are regarded as encysted colobomata (p. 410). Other cases are supposed to arise from fœtal inclusion of a portion of the lacrimal sac.

Parasitic Cysts are usually caused by the echinoccocus, while the cysticercus is much rarer in the orbit. Several of the former have been observed in England. They generally are deeply situated, and the first symptom is severe pain in the head, like hemicrania.

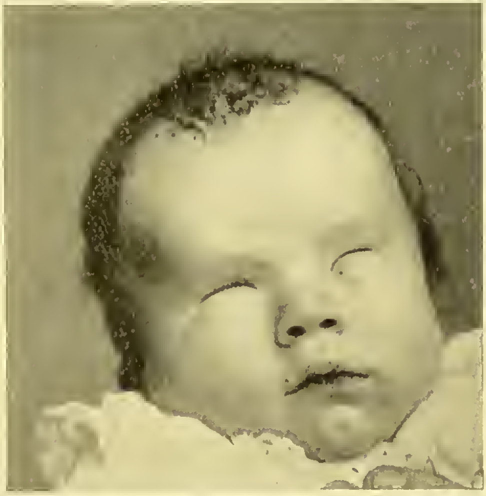

FIG. 217.—A case of so-called anophthalmos, with a cyst in the left lower lid.

Treatment.—The cyst should be removed *in toto*, if possible. To do this, Krönlein's operation (p. 667) may be resorted to. Or, a horizontal incision may be made along the orbital margin through the eyelid, in order that the cavity of the orbit may be reached, or two perpendicular incisions at either canthus through the upper lid may be made, and the latter turned upwards. With hooks or forceps, and scalpel or scissors, the cyst wall must then be carefully separated from all adhesions. If it cannot be removed entire, as large a portion of the wall as possible should be taken away, and the contents evacuated by gentle pressure backwards of the eyeball, and the sac syringed out two or three times daily with an antiseptic solution, until all discharge has ceased. The above treatment does not, of course, apply to encephalocele, which cannot as a rule be interfered with.

Solid tumours of the orbit are in most instances malignant (sarcoma), but may be benign (exostosis, angioma, fibroma), and vary in consistency from the softness of the angiomata to the dense hardness of the ivory exostoses.

Exostoses occur as the result of faulty development of the bones, and also without any apparent cause, and are usually of the kind known as ivory exostoses. Three-fourths of them begin before the twenty-fifth year of age. They spring most commonly from the ethmoid or from the frontal bones, and have a broad base, but are sometimes pediculated.

All the bony tumours give, of course, the sensation of dense hardness to the touch; but there are some malignant growths of such hardness that it may not be easy to tell them from the osteomata by palpation, and an exploratory puncture becomes necessary in order to decide the point. The growth of an orbital osteoma is excessively slow, in many instances commencing in infancy, and lasting into advanced life. In addition to the dense hardness of these tumours, the deciding points in the diagnosis are their smooth, usually globular, and somewhat nodulated surface, and their immobility and direct connection with the walls of the orbit, ascertainable by touch.

Operative interference, in cases of exostosis of the orbit, is only justifiable when the tumour does not grow from the roof of the orbit (as it then often involves the cranial cavity), and when there is reason to think it is attached to the orbital wall by a narrow base or pedicle. Several instances are on record in which the growth has become spontaneously separated by necrosis of its pedicle. Beyond destruction of the eyeball there is no danger associated with these tumours, even if their growth take an intracranial direction; but they cause serious disfigurement and much pain.

Angiomata may be simple or cavernous. They are usually soft, compressible, and painless, are very slow in their growth, and do not give rise to pulsation or bruits. The teleangiectases, or simple tumours, are usually congenital, and are often merely extensions into the orbit of angiomata of the eyelid. The cavernous form is often encapsuled. A few cases of lymphagioma have also been met with in the orbit.

Sarcoma.—Malignant tumours of the orbit are nearly always sarcomata, many different varieties of which are met with. Primary carcinoma of the orbit can only originate in the lacrimal gland. Sarcoma may develop in the connective tissue in any part of the orbit, most frequently, perhaps, in the periosteum and in the connective tissue about the lacrimal gland. Or it may arise from the endothelium of the vessels (endotheliomata), and if it be very vascular, it may pulsate, without, however, giving rise to a murmur. These malignant tumours, after destruction of the eyeball by pressure, or by phthisis following ulceration of the cornea, attack the bony walls of the orbit and its surroundings.

The early extirpation of the tumour with complete evisceration of the orbital contents affords, in general, the only prospect, and that a slight one, of saving the patient's life.

Some forms of sarcoma, however, are non-malignant, especially those which lie free in the orbit and arise from the connective tissue. Indeed, Panas held that many cases of sarcoma, as also of lymphadenoma of the orbit, are due to infectious principles, toxins, or microbes, and are amenable to medical treatment by mercury, iodine, arsenic, or toxitherapy. So much certainly must be admitted—

namely, that cases now and then present themselves, with all the signs and symptoms of orbital tumour, which ultimately undergo a purely spontaneous cure, or one unexpectedly brought about by iodide of potassium.

Attention has recently been drawn to these pseudotumours by Birsch Hirschfeld.[1] In some cases no tumour is found, in spite of the existence of exophthalmos, etc., while in others a chronic inflammatory condition of the connective tissue alone exists. We have ourselves seen a large sarcoma-like orbital tumour, which, on removal, proved to be merely a mass of inflammatory tissue.

Symmetrical Tumours of the Orbits.—With the exception of tumours of the lacrimal glands, and possibly of rare instances of metastatic tumours, symmetrical tumours of the orbits are almost invariably lymphomata or lymph-adenomata, occurring in leucæmia or in pseudo-leucæmia.

Pulsating Exophthalmos.—This is most frequently due to arterio-venous aneurism in the cavernous sinus, which may be either traumatic or spontaneous. The symptoms are: proptosis; the presence of peculiar bruits, which can be heard over the orbit, and usually, also, over a more or less extensive portion of the skull; pulsation, apparent in the eyeball, or at some point of the orbital aperture, and often a thrill can be felt with the fingers placed on the upper lid. The two latter symptoms may occasionally be absent during the whole, or part, of the progress of the case. The same symptoms may be exceptionally caused by aneurism of the carotid in the cavernous sinus, aneurism of the ophthalmic artery at its origin, or in the orbit, and by cirsoid aneurisms, or by very vascular malignant tumours. It is also possible that obstruction of the cavernous sinus from other intracranial causes may produce these symptoms.

Hæmorrhage is liable to prove fatal in these cases.

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[1] *Ophthalm. Gesellschaft*, Heidelberg, 1905.

Treatment.—Ligature of the common carotid affords the best prospect of cure. Digital compression of the same vessel has produced cure in some cases. Spontaneous cure has been observed occasionally in cases of arterio-venous aneurism.

Intermittent Exophthalmos.—This is due to a varicose condition of the veins of the orbit. The exophthalmos only occurs on stooping, or on exertion, and can be produced by compression of the jugular vein in the neck. In the erect position there is often enophthalmos. Sometimes dilated veins are visible in the eyelids. Tumours and cysts of the lacrimal gland also occur in the orbit (p. 335).

Tumours of the Optic Nerve.—These are rare affections. They occur at all times of life, but the majority of the patients are under twenty years of age. The tumour usually commences about the middle of the course of the nerve, and usually does not extend to the bulbar end. The symptoms are:—Slowly increasing protrusion of the eyeball, in a direction most usually directly forwards, or forwards and outwards (Fig. 218). The motions of the eyeball are not greatly restricted, and the centre of its rotation is not displaced, owing to the tumour being within the cone of the orbital muscles. The proptosis is unaccompanied by pain. The sight becomes very defective, or is quite lost at a very early stage, from interference with the functions of the nerve by the tumour or by the optic neuritis, or optic atrophy, to which it gives rise. The tumour is sometimes very soft, so that the eyeball can, as it were, be pushed back into it, and the pressure does not cause pain. The pupil reacts consensually. The tumour may often be felt by palpation in the orbit. The patient's health does not suffer.

The diagnosis between a new growth of the optic nerve and one of its sheath can hardly be made with certainty; but the existence of fairly good vision, while other symptoms are as above, at a rather late period of the proptosis, would point to the sheath as the seat. Such a diagnosis would be important, for it may be possible to remove, by Krönlein's operation, a tumour of the sheath of the optic nerve, while preserving not merely the eyeball, but good vision as well.

These tumours are either myxo-sarcomata, or, less frequently, endotheliomata, and are usually intra-dural or encapsuled by the sheath of the nerve. Extra-dural tumours are still rarer. Both varieties are benign, in the sense that they do not lead to glandular enlargements or to metastases; but in some cases death occurs from extension of the disease to the cranial cavity, or from the sudden development of intracranial growths, which coexisted with the optic nerve tumour. This complication may occur many years after removal of the tumour of the nerve. Local recurrence is less common, but in one case a recurrence took place in the orbit twenty-six years after operation.

Treatment.—To remove these tumours three methods are available, namely :- (1) Removal of the eyeball with the tumour ; (2) Krönlein's operation, by means of which the optic nerve tumour may, probably in most instances, be removed without the eyeball ; and (3) Knapp's operation, also for removal of the tumour without the eyeball. It is unnecessary to describe the first of these procedures, which follows very much the lines of an ordinary excision of the eyeball, except that the optic nerve is divided as far back in the orbit as possible. Krönlein's operation is described on p. 667.

Knapp's operation is as follows:—The tendon of the internal rectus is divided so as to leave a portion adherent to the sclerotic of about 5 mm., the cut end being secured by a suture passed through it, to prevent it from retracting into the orbit. The eyeball is then forcibly everted outwards, a strong scissors is passed into the orbit, and the optic nerve is divided as close to the optic foramen as possible. The globe is now further everted outwards, to expose its posterior surface with the tumour attached, and the latter is removed by dividing the optic nerve close to the eyeball. Finally, the eyeball is reposed, the cut ends of the tendon of the muscle united, and the opening in the conjunctiva closed. A drawback to this operation is, that it is not always possible to be certain that the deep portion of the tumour is reached with the scissors.

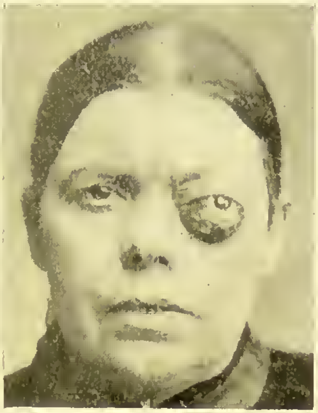
FIG. 218.—Tumour of the Optic Nerve.

Lagrange passes a ligature or loop over the tumour, divides the nerve as far back as possible, draws the tumour out, and thus exposes the back of the eyeball, from which the tumour is then removed. Fig. 218 is a case of tumour of the optic nerve and Fig. 219 represents the same case after operation by Krönlein's method.

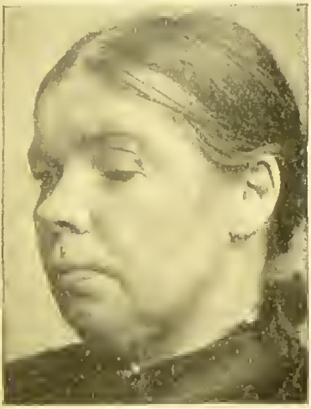
FIG. 219.—The same patient as in Fig. 218 after Krönlein's operation.

Implication of Neighbouring Cavities.—As regards the question whether the tumour is confined to the orbit, or involves one or more of the neighbouring cavities, it may be assumed that it is confined to the orbit, unless there are symptoms or signs which point in the opposite direction; and in each case these symptoms and signs ought to be looked for. Tumours may either originate in one of these spaces and grow into the orbit, which is the more common event; or, originating in the orbit, they may spread to a neighbouring space; and it is often the history or progress of the case alone that can inform us which of these events has taken place.

When disease (mucocele, empyema, tumours) of the accessory sinuses of the nose involves the orbit, the symptoms which ensue may be due to the effect of the pressure exerted by the over-distended sinus, or to septic infection, or to a combination of these. The pressure effects are produced by the formation of a tumour-like projection of some portion of the orbital wall corresponding to the position of the affected sinus. This leads to displacement of the eyeball with exophthalmos and limitation of movement, and the sight may be impaired or lost from optic neuritis, or from atrophy of the optic nerve. If the sphenoidal, or posterior ethmoidal sinus be diseased, impairment of vision in one or both eyes may be the only symptom in the early stage. This is due to the fact, that the inner boundary of the optic canal sometimes forms a portion of the wall of these sinuses, and may be extremely thin on one or both sides, thus rendering the optic nerve particularly vulnerable. The nerve generally shows signs of inflammation or atrophy, but on the other hand it may be normal, as in retrobulbar neuritis from other causes (see p. 547), and the defect of vision may only reveal itself as a central scotoma (Fuchs).

If septic infection take place, orbital cellulitis and its consequences (p. 642) result. Infection is usually preceded by perforation of the orbital wall, but it may be carried into the orbit by emissary veins, or through small foramina, or congenital dehiscences in the bones.

Mucocele or empyema is sometimes indicated by a history of influenza, or post-nasal catarrh, followed by purulent discharge from the nose. In all cases, a careful examination of the nose should be made, aided, if necessary, by transillumination and the X rays. It should be remembered, however, that empyema of a sinus, with implication of the orbit, may sometimes exist without any appearance of nasal disease, if the channel of exit from the sinus be completely occluded.

The *Frontal Sinus* begins to form at about the seventh year of age, and continues to increase in size from that time onwards. Disease of this sinus, therefore, is only met with in adults. It frequently extends to the ethmoid, and sometimes leads to maxillary empyema. There may be some redness and swelling at the inner extremity of the eyebrow, with tenderness on percussion, and the patient sometimes suffers from paroxysmal attacks of frontal neuralgia, but again in this, as in the case of other sinuses, the pain may be diffuse, and not in any way characteristic. A tumour forms at the upper and inner angle of the orbit, and displaces the eye downwards and outwards. In some cases a fistula appears above the position of the lacrimal sac, and fluid may appear in the nostril on syringing it. Rarely, a frontal mucocele may form a subperiosteal collection in the roof of the orbit, and point at the outer side of the latter, as in a patient under the care of one of us. Osteoma of the frontal sinus shows itself as a slowly growing and densely hard tumour, almost free from pain, situated along the superior margin of the orbit, extending into the latter and pushing the eyeball downwards and forwards. It may subsequently extend to the orbital plate of the ethmoid, and may be mistaken for an exostosis of the orbit. Bony growths originating in the orbit may invade the frontal sinus, and, whether originating there or in the sinus, are liable to produce absorption of the tables of the skull without any cerebral symptoms to indicate the occurrence.

Tumours of the *Ethmoid Cells*, which encroach upon the orbit, are likewise most commonly either mucocele or osteoma. Mucocele of the ethmoid cells presents itself in the orbit as a smooth tumour, on the inner wall of the orbit, giving rise to displacement of the lacrimal bone (with, perhaps, a sense of fluctuation and crackling on palpation), and pushing the eyeball outwards and forwards. There is sometimes a feeling of pressure on the bridge of the nose. Nervous symptoms, such as mental dullness, hypochondriasis, etc., may be present. Mucocele of the ethmoid cells encroaching on the orbit must also be distinguished from a dermoid cyst (p. 652). Osteoma of the ethmoid appears in the orbit as a hard round swelling at the inner canthus, followed by a swelling of the cheek and displacement of the eye outwards and forwards. It is apt also to extend into the nasal meatus, driving the septum out of place, and pushing the hard palate downwards, so that examinations of the nose and of the mouth should be made in aid of the diagnosis. Enchondromata and fibromata sometimes spring also from the ethmoid, and extend into the orbit, and malignant growths may be met with here.

Tumours originating in the Body of the *Sphenoid* Bone, or in the Antrum of the Sphenoid, and encroaching upon the orbit are rare, and the diagnosis of their origin in an early stage is practically impossible. They may cause pain in the occipital region, and, as stated above, optic atrophy may be an early symptom. It is said (Stedman Bull) that an orbital tumour which soon causes blindness, commencing in the temporal side of the field, and leaving the fixation point unaffected to the last, while at the same time a growth appears in naso-pharynx, is likely to be one having its origin in the sphenoid antrum. Bony tumours—osteoma, hyperostosis, and exostosis—polypi, and sarcomata, are the growths most frequently found to originate in the sphenoid antrum.

Tumours of the *Maxillary Antrum* sometimes push the floor of the orbit upwards, or erode it, and grow into that cavity, driving the eyeball upwards and inwards, or upwards and outwards. The breadth of the cheek is increased, the nose becomes pushed towards the opposite side, and the roof of the mouth is pushed downwards. Tumours of the antrum of Highmore sometimes cause pain in the teeth, or in the region of distribution of the infraorbital nerve, and there may be a dull pain in the region of the antrum. In some cases there is a discharge of pus or of blood from the nostril. Empyema of the antrum may give rise to orbital cellulitis commencing at the lower part of the orbit, with swelling of the lower lid, and chemosis of the conjunctiva below the cornea.

We have seen two cases of malignant disease, one of the maxillary antrum, and the other in the nasal fossa, in which epiphora was the first symptom complained of by the patient.

Intracranial Tumours do not often invade the orbit. When they do so they originate in the middle fossa, and gain access through the sphenoid fissure and optic foramen. The diagnosis of the origin of the disease can only be made, if cerebral symptoms have existed prior to any sign of a new growth in the orbit. Tumours of the pituitary body may encroach upon the orbit by way of the sphenoid fissure, and are apt to be associated with polyuria and bitemporal hemianopsia, which assist the diagnosis.

A more common event, although not in an early stage of the growth, is the extension of a primary orbital tumour to the brain, either along the optic nerve, through the sphenoid fissure, or through the roof of the orbit by erosion of the bone. This occurrence is usually evidenced by the presence of cerebral symptoms; but cases have been met with where no such symptoms existed, although the orbital growth had encroached upon the anterior or middle fossa of the skull.

***Shrinking of the Conjunctiva (Xerophthalmos) and of the Subconjunctival Tissue of the Orbit, subsequent to Enucleation of the Eyeball.**—In some cases where the eyeball has been excised, and in due course a prothesis fitted, the conjunctiva and subconjunctival tissues shrink to such a degree, after some months or years, as to reduce the size of the orbital cavity so that the wearing of a glass eye becomes impossible. This is especially liable to occur amongst those hospital patients, who are careless in removing the prothesis at night, and in keeping the socket thoroughly clean at all times. The attempt is then often made to restore the orbital cavity, so as to render it possible to wear at least a small glass eye, by means of skin grafts, or of mucous membrane grafts, after the method either of Thiersch or of Wolf. The success attendant on these procedures is usually a very moderate one, and often not permanent, owing to subsequent renewed shrinking of the subconjunctival tissue.

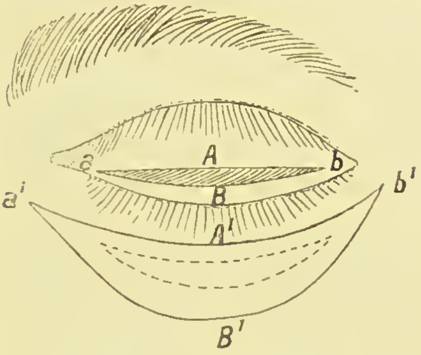

FIG. 220.

In these cases the lower sulcus is the most important part of the cavity, and if it can be made sufficiently deep, a small artificial eye will be retained. With this object in view, Mr. P. W. Maxwell, of Dublin, has devised the following operation :—

An incision is made in the floor of the socket, and carried downwards behind the lower lid. A semi-lunar flap, about 8 mm. in width at its widest part, is marked out on the skin of the lid, its upper concave border being about 5 mm. below the palpebral margin. The incision along the upper border of the flap is made to communicate with the bottom of the wound in the socket. The flap is now dissected up from the subcutaneous tissue, except an area represented by the dotted line in Fig. 220. The two ends of the flap (a' and b') are passed through the opening into the socket, and sutured to each end of the socket incision (*a* and *b*); and the borders *A′* and *B′*, being also passed through, are sutured to *A* and *B* respectively. The space on the cheek is closed, and the operation completed by inserting into the socket a temporary glass eye or shell. This should be as nearly as possible of the size and shape of the eye to be ultimately worn; it prevents the new sulcus from being obliterated by contraction, and gives it a suitable shape. It cannot safely be taken out for at least a week, as the skin incision might perhaps be opened in so doing. If there be secretion, the space behind may be flushed out by a lacrimal syringe armed with a fine curved nozzle, which can be introduced under the edge of the eye at the inner or outer canthus. A glass shell with a hole in front is preferable to a glass eye, for it allows a syringe to be more easily used, and, being transparent, a view of the parts behind can be obtained.

To obtain a good result the following points should be attended to:

1. Make the incision in the socket as long as the space will permit, and see that this length is maintained throughout its entire depth.

2. Make the skin flap considerably longer than the incision in the socket.

3. When dissecting up the skin flap, leave undisturbed a portion (dotted line in figure) equal in length to the socket incision. This subsequently forms the fornix, or sulcus. If a shorter portion is left, the sulcus is apt to become V-shaped, which would require a specially made glass eye.

4. When closing the space on the cheek, as the lower border is longer than the upper, great care should be taken to equably distribute the excess, so as to avoid puckering. When this has been neatly done, the line upon the face becomes quite invisible after a few months.

In none of the cases, so far, has it been necessary to make a sulcus above. The same operation could, however, be performed on the upper lid, provided that, after dissecting up both the borders of the skin flap, the tendon of the levator were secured with one or two sutures before dividing it. After the skin flap is in its new position, the cut end of the levator could be attached to the tarsus. In closing the skin wound, the ends of these deep sutures should be allowed to project outwards, so that they may be pulled out when they ultimately become loose. If it were possible to obtain thoroughly aseptic catgut, the ends of the sutures might be cut short and buried.

In addition to providing a sulcus, the operation adds half the width of the flap—viz., 4 mm.—to the vertical diameter of the socket.

If there be much cicatricial contraction, the above operation is not sufficient and it is better to transplant skin flaps (dermal or epidermal) from the arm to the spaces made by freeing the lids. The dissection of the lids should be deep, and all fibrous bands should be thoroughly divided. Either of two plans may be adopted. In the first the conjunctiva is dissected from the lid margin, and the island of mucous membrane thus formed furnishes the covering for the central, or apical portion of the new socket, while the lids and artificially made fornices are clothed with the flaps from the arm. Or, secondly, the conjunctiva may be divided horizontally in the centre, and dissected up, except where it covers the tarsus, and the skin flaps may be used to cover the back of the orbit, and posterior surfaces of the newly made fornices.

The great difficulty in all these operations consists in keeping the flaps in close apposition with the soft and yielding tissues of the orbit, and therefore it is necessary to support the flaps, and retain them in position, with some solid material, such as guttapercha or lead, which can be cut and moulded to fit the orbital cavity and fornices. The flaps may, if necessary, be wrapped round the artificial support, raw surface outwards, and fastened to it with sutures. After the insertion of the flap and shell, the edges of the lids are temporarily sewn together, and opened again in about a week.

Grünert adopts the first method, and then divides the outer canthus and frees both lids, so that they can be fully everted. The lids are then well everted, and sutured respectively to the brow and cheek. The skin flaps are thus easily applied, and good contact can be ensured by pressure of a bandage. After a couple of weeks, the lids can be replaced, and the outer commissure re-united.

***Temporary Resection of the Outer Wall of the Orbit (Krönlein's Operation).**—This operation was devised by Professor Krönlein, of Zürich. It is well suited for the removal of tumours of the optic nerve, and other new growths and cysts in the posterior part of the orbit, as well as foreign bodies, without sacrificing the eyeball, or perhaps even the sight. It may also be employed to reach purulent foci in the orbit, and has been used to remove some of the retrobulbar fat in cases of exophthalmic goitre.

The eyebrow and the scalp in the temporal region are shaved, and the skin of the whole region of the operation is rendered aseptic.

The First Stage of the operation consists in making a curved incision on the temple through the skin and soft parts. This incision commences on the temporal ridge, at a point where the latter would be intersected by a horizontal line running 1 cm. above the supraorbital margin. The middle point, or apex, of the incision lies in the centre of a horizontal line, which unites the external canthus with the outer orbital margin. The end of the incision lies on the zygoma, in the centre of a horizontal line uniting the external canthus with the tragus. The length of the incision in adults is 6 to 7 cm., and the direct distance between its two ends is about 5 cm. Smaller incisions are inconvenient. In that portion of the incision which runs along the margin of the orbit it goes to the bone, through the periosteum.

The Second Stage consists in raising the periosteum from the inner surface of the outer wall of the orbit with a slightly curved and somewhat pointed elevator, which is introduced at the exposed outer orbital margin. The periosteum is separated upwards as far as 1 cm. above the fronto-malar suture, downwards as far as the spheno-maxillary fissure, and posteriorly until well behind the spheno-zygomatic suture. This proceeding is not difficult, as the periosteum is closely adherent along the orbital margin only, and at the sutures. The point of the elevator is now passed directly downwards, and carefully introduced into the spheno-maxillary fissure a few millimetres behind the spheno-zygomatic suture. The handle of the instrument is then turned over gently towards the nose, thus pressing the periosteum and all the contents of the orbit somewhat inwards, and exposing the bared inner surface of the outer orbital wall. The object of passing the point of the elevator into the spheno-maxillary fissure—where it remains during the next stage of the operation—is to fix the point towards which the osseous incisions are to be made to converge. Some surgeons prefer to omit this act, and the proximity of the infra-orbital nerve, and of the infra-orbital vessels, must be borne in mind.

The Third Stage is the resection of the bony wall by three incisions, two horizontal and one oblique. The upper horizontal bony incision is made with a thin, sharp chisel, and divides the external angular process of the frontal bone close to its base. The soft parts have been previously drawn aside, the periosteum over the seat of the proposed bony incision divided and, along with the lacrimal gland, drawn aside.

The oblique bony incision passes from the deepest part of the previous incision downwards and backwards behind the spheno-maxillary suture, through the greater wing of the sphenoid bone, to a point about 1 cm. behind the anterior end of the spheno-maxillary fissure, where the point of the elevator has been kept all through.

The lower horizontal bony incision divides the frontal process of the malar bone close to its base, the soft parts having been drawn aside, and the periosteum divided. The incision ends at the anterior extremity of the spheno-maxillary fissure.

In making the bony incisions there is the danger of splintering to be contended with, and in the oblique incision there is some danger of luxating the spheno-maxillary suture. The chisel must be very sharp and thin, and it is well to apply its corner rather than its full edge to the bone, while only light taps with the mallet are used. It is important to make the bony incisions in the above order; or, at any rate, the oblique incision should not be the last to be made, for, if it be, the thin outer wall of the orbit is liable to become severely splintered during the chiselling of the second bony process.

The Fourth Stage is the turning backwards of the flap of bone and soft parts, and the exposure of the interior of the orbit. After the flap has been turned well back, the separated periosteum is divided with a blunt-pointed scissors, from before backwards. It is sometimes necessary, in order to reach the focus of disease, to divide the tendon of the external rectus near its sclerotic insertion, and possibly other orbital muscles must be severed; but this should be avoided, if possible.

When all manipulations required in the orbit have been completed, any muscles which may have been divided are sutured to their insertions, the periosteum is replaced in its normal position, the flap of bone and soft parts turned forwards into its place, and secured there by a few catgut sutures through the periosteum. A drain is then placed in the lower part of the wound, and the rest of the wound is accurately closed with fine silk sutures, and an aseptic dressing and bandage applied. The catgut sutures through the periosteum, and the drain, are regarded by several operators as unnecessary.

We have performed the operation for tumour of the optic nerve (see Fig. 219), for a mucocele of the frontal sinus which extended out under the roof of the orbit, and for diagnostic purposes in a case of pulsating exophthalmos, and have found it very satisfactory. The resulting scar is not disfiguring (see Fig. 219).

Exophthalmic Goitre (Graves' Disease, Basedow's Disease).

Symptoms.—The three cardinal symptoms of this disease are: increased rapidity of the heart's action, which may reach two hundred beats per minute; tumefaction of the thyroid gland; and exophthalmos. Of these the cardiac symptom is the most constant, and usually the first to appear; either, or both of the others, may be wanting. There is often also great emaciation (Fig. 220), with outbursts of sweating and diarrhœa. A venous murmur may be heard in the neck; and in females there is very commonly irregularity or suppression of menstruation.

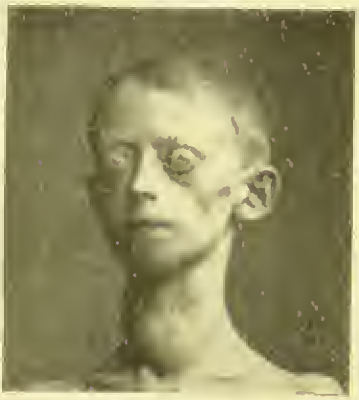

Fig. 221.—Exophthalmic goitre, accompanied with great emaciation, in a young lad.[1]

The disease has been observed at all ages, but is most common in early adult life.

Von Græfe's Sign is a very early, tolerably constant, and almost pathognomonic one: it consists in an impairment of the consensual movement of the upper lid in association with the eyeball. When, in the normal condition, the globe is rolled downwards, the upper eyelid falls, and thus its margin is kept throughout in a constant relation to the upper margin of the cornea. In Graves' Disease the descent of the upper lid does not take place, or does so imperfectly; and, consequently, when the patient looks down, a zone of sclerotic becomes visible between the margin of the lid and the cornea. This symptom is often present prior to any exophthalmos, and hence its great diagnostic value. It may also continue after the latter disappears,—although it is perhaps more common for it to disappear before the proptosis,—and it is not seen, or but very rarely so, in protrusion of the globe from other causes. But the sign is not so absolutely pathognomonic as it was held to be by von Græfe; for it may be absent in Graves' Disease, although very rarely so, in the early stages, and it is sometimes present in other diseased states, and even in health.

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[1] We are indebted to Dr. Martin Dempsey for the photograph of this patient.

Stellwag's Sign, incompleteness and diminished frequency of the act of involuntary nictitation, is also very constant.

This act occurs sometimes only once in a minute: or several rapid nictitations take place, and then a lengthened pause. The nictitation each time is incomplete, the margins of the lid not being brought together. The result may be that the lower third of the cornea becomes covered with pannus vessels, owing to the constant exposure; for even during sleep the eyelids remain partially open.

Dalrymple's Sign consists in an abnormal widening of the palpebral aperture, due to retraction of the upper eyelid. It is this gaping of the eyelids which gives the characteristic staring aspect to the patient. This sign is often erroneously attributed to Stellwag, or is included in his sign.[1]

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[1] Other conditions which produce widening of the palpebral aperture or "Staring Eye," are:—(1) Orbital Tumour (mechanically). (2) Stimulation of the Cervical Sympathetic. (3) Cocaine (in slight degree, probably by reason of 2). (4) Women after child-birth (hysteria). (5) In tetanus (spasm of occipito-frontalis). (6) In complete amaurosis.

Insufficiency of convergence has been observed by Moebius and is called Moebius' Sign, but it is not always present and is, we think, merely indicative of general nervous debility and not of any importance as a sign of Graves' Disease.

Probably the three first 'signs' are due to the one cause —namely, loss of power in the orbicularis, rather than over-action of the levator.

Spontaneous pulsation in the retinal arteries is said to occur, but it must be exceptional. The vision—unless when corneal complications supervene—and condition of the pupil are unaffected by the disease. In some cases there is an increased flow of tears, but most of the patients complain of a dryness of the eyeballs. The sensibility of the cornea is diminished. Ulcers of the cornea are not common, but are said (von Græfe) to be more frequent in men than in women, although Graves' Disease is more common in women. The exposure of the eye and dryness of the cornea are the chief causes of ulceration, when it occurs; but Sattler inclines to the belief that it is also largely due to paralysis of the nervous supply of the cornea.

The patients are often hysterical; and even marked psychical disturbances have been noted, such as a peculiar and unnatural gaiety, rapidity of speech, and great irritability; or, on the other hand, extreme depression, and even attempts at suicide have been observed. Also loss of memory and inability to make a mental effort. The motions of the eyeball have in some cases been defective—a fact for which the exophthalmos does not account. Well-marked muscular tremors are frequently present and Trousseau's Cerebral Macula is often seen.

The Progress of the Disease is, as a rule, very chronic, extending over months or years, but liable to fluctuations in the intensity of its symptoms. A few cases have been recorded in which it became fully developed in the course of some hours or days. After a lengthened period, and many fluctuations, the symptoms usually slowly disappear. Occasionally a slight permanent swelling of the thyroid may remain, and very often more or less exophthalmos. About 12 per cent. of the cases go from bad to worse, and end fatally from general exhaustion, organic disease of the heart which may have come on, cerebral apoplexy, hæmorrhage from the bowels, or gangrene of the extremities.

Causes.—Anæmia and chlorosis are general conditions very often present, as are, also, irregularities of menstruation; but it is probable that the latter should be regarded rather as a concomitant symptom than as a cause. Severe illnesses are recorded as having gone before the onset in many cases, and also excessive bodily or mental efforts. Great sexual excitement has been known to be followed by Graves' Disease, and depressing psychical causes are not unfrequent forerunners of it. In many instances, however, the patients have been perfectly healthy, and no cause could be assigned.

The Enlargement of the Thyroid is due in the first instance to dilatation of its vessels; but in a late stage hypertrophy of the gland tissue may be produced, and increase of its connective tissue, and even cystic degeneration. The Exophthalmos is due to hyperæmia of the retro-bulbar orbital tissues, as is demonstrated by a vascular bruit often present, and the fact that steady pressure on the globe diminishes the protrusion. Hypertrophy of the orbital fat may be found *post mortem*, but is, doubtless, secondary to the hyperæmia.

With regard to the nature of the disease, very many theories have, from time to time, been put forward, but none is quite satisfactory, and a discussion of them does not come within the scope of this work.

Treatment.—A principal part of this consists in the careful regulation of the patient's general health and functions. Freedom from mental anxiety and excitement, regular hours, moderate exercise, and change of air are the most important items.

The fluctuations, which occur in the intensity of the symptoms, render it difficult to arrive at definite conclusions with regard to the efficacy of remedies, a vast number of which have been tried and lauded from time to time. In mild forms of the affection, and especially if the anæmia be well marked, iron internally is beneficial, but in severe cases it has the opposite effect. Quinine in moderate doses has been employed with benefit in some cases. Trousseau recommended digitalis in large doses, but its effect must be watched. The beneficial action of iodide of potassium in ordinary goitre has suggested its use in this disease; but under its influence the symptoms are sometimes aggravated, and it is doubtful whether they are ever relieved by it. Hulke praised aconite highly, and Sir Samuel Wilks has no doubt as to the value of belladonna. Ergotin internally has been tried, and with advantage in some instances. Sattler warmly recommends a well-regulated hydropathic treatment, when the patient is not too excitable. Paroxysms of cardiac palpitations, etc., are best combated by ice applied to the head, heart, and goitre. The sympathetic theory has induced the trial of a galvanic treatment of the cervical sympathetic.

Gauthier recommends antipyrin before everything else. Extract of the thymus gland has been occasionally employed, and with encouraging results.

Partial extirpation of the thyroid has been performed in recent years with success in some cases.

The great number of remedies which have been proposed for the disease demonstrates its intractable nature. Yet a considerable proportion of the cases do undergo cure, in so far as quieting of the heart's action, and reduction, or, possibly sometimes, complete disappearance, of the goitre and exophthalmos, are concerned. It is common, however, even in the best recoveries, to see some exophthalmos remain permanent'y.

In cases where the exophthalmos is so great that the cornea is exposed even during sleep, it is desirable to perform tarsoraphy (p. 301); and the same operation is indicated when, the disease having subsided, the exophthalmos still remains to a degree which gives the patient a disagreeable expression.

*CHAPTER XX.

Part I.—Ocular Diseases and Symptoms liable to accompany Focal Disease of the Brain.

Part II.—Ocular Diseases and Symptoms liable to accompany Diffuse Organic Diseases of the Brain.

Part III.—Ocular Diseases and Symptoms liable to accompany Diseases and Injuries of the Spinal Cord.

Part IV.—Nervous Amblyopia, or Asthenopia.

Part V.—Various Forms of Amblyopia.

Part I.

OCULAR DISEASES AND SYMPTOMS LIABLE TO ACCOMPANY FOCAL DISEASE OF THE BRAIN.

Hemianopsia (ἥμισυς, *half*; *a*, *priv.*; ὤψ, *the eye*).—This symptom consists in a loss of sight in one-half of the field of vision, usually of each eye, consequent upon a lesion at the cortical centre for vision, at the optic commissure, or at some point in the course of the visual path between these two places. It is not used for cases in which one-half of the field is lost, owing to disease within the eye itself.

In hemianopsia the line dividing the seeing from the blind half of the field passes vertically down the centre of the latter, as in Fig. 222. Sometimes this line lies a little to one side of the centre of the field, so as to admit of the centre being included in the seeing part, as in Fig. 223; and sometimes—although in other respects the dividing line lies in the centre of the field—the fixation point is circumvented by it, so as to leave that point free, as in Fig. 224; and this latter is the most common arrangement.

Furthermore, cases occur which are properly regarded as hemianopsia, and yet in which only the upper or the lower half of one side of the field is wanting, as in Fig. 225. Figs. 222, 223, and 224, would be called complete hemianopsia, while Fig. 225 would be termed incomplete or partial hemianopsia. If all three visual perceptions be lost, the hemianopsia is called absolute; but if only one (colour) or two (colour and form) be wanting in the defective part of the field, it is termed relative hemianopsia. Relative hemianopsia is a result of a lesion of less intensity than that which causes absolute hemianopsia. The vast majority of cases of hemianopsia are absolute.

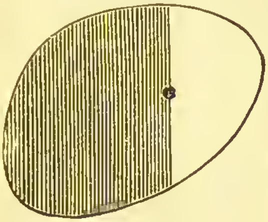

FIG. 222.[1]

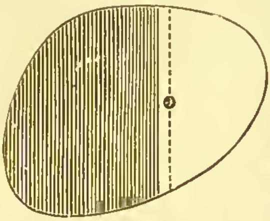

FIG. 223.

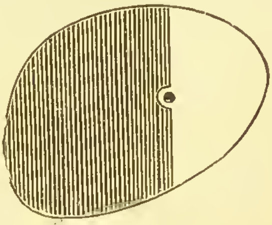

FIG. 224.

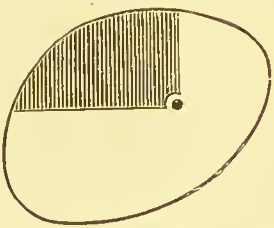

FIG. 225.

Homonymous Hemianopsia is the most frequent form. In it the corresponding half—the right half or the left half—of the field of each eye is wanting, as in Fig. 226, in which the left side of the fields, from the patient's point of view, is blind, implying a loss of function in the right half of each retina.

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[1] Figs. 222, 223, 224, and 225 are diagrammatic representations of the left field of vision.

Bi-Temporal Hemianopsia is much less common. In it there is loss of vision in the outer side of each field, in consequence of loss of sensibility in the mesial half of each retina (Fig. 227).

Superior or Inferior Hemianopsia, also called Altitudinal Hemianopsia, in which the upper or lower half of the field is blind, is exceedingly rare; and it is doubtful whether Nasal Hemianopsia has really been observed, although it has been described. In the latter form the inner side of the field of one eye only is lost.

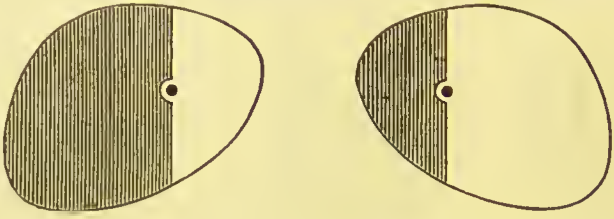

FIG. 226.

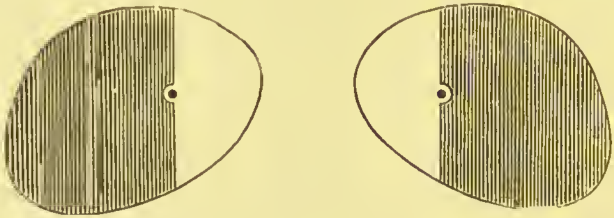

FIG. 227.

It will be convenient here to sketch

The Course of the Visual Path from the Retina to the Visual Centre in the Cortex of the Brain.

Having passed along the optic nerve, the visual fibres coming from the mesial half of each retina, when they reach the optic commissure, cross to the opposite optic tract, while those from the temporal side of each retina are continued in the tract of the same side. In other words, the visual fibres from the homonymous half of each retina—*e.g.*, from the temporal half of the right retina, and from the mesial half of the left retina—pass wholly through the corresponding optic tract—in this case the right tract—on their way to the primary optic ganglia. Therefore a lesion, say, of the right tract, would cause loss of function of the corresponding half—the right half—of each retina, and the symptom would be blindness of the opposite half—the left half—of each field of vision, termed left homonymous hemianopsia.

The primary optic ganglia are:—the external geniculate body, the pulvinar of the optic thalamus, and the anterior quadrigeminal body. It is the external geniculate body which receives the major portion of the fibres from the optic tract, and it is the only one of the primary optic ganglia, which all observers unhesitatingly connect with the act of vision. Its lesion invariably gives rise to homonymous hemianopsia. Some of the fibres, which enter the external geniculate body, end in the grey matter contained in it, but the majority pass on into the pulvinar of the optic thalamus, which also receives direct fibres from the optic tract. Notwithstanding this, lesions of the pulvinar do not invariably cause hemianopsia, a clinical fact for which an explanation cannot as yet be given. The superior quadrigeminal body receives a small portion of the optic tract fibres, but these are not visual fibres, and lesion of this body is never attended by hemianopsia. From the axons of the nerves, in the external geniculate body and pulvinar, fibres pass, by way of the retro-lenticular portion of the posterior limb of the internal capsule, to the optic radiation, a large strand of fibres which run in the central white matter of the hinder part of the cerebral hemisphere, and which terminate in the cortex of the occipital lobe. Lesions of the optic radiation cause homonymous hemianopsia. It is remarkable that, although anatomically fibres can be traced, as stated, passing from the pulvinar to the optic radiations through the retro-lenticular portion of the internal capsule, yet there is much doubt as to whether lesions in the latter place cause hemianopsia, and it may be that the visual path passes more directly into the optic radiation.

From the internal capsule the optic radiation sweeps back, on the outer side of the posterior horn of the lateral ventricle, to reach the mesial surface of the occipital lobe, where the cortical centre for vision is situated. Henschen, as a result of his clinico-pathological researches, would confine the cortical centre for vision to the middle part of the calcarine fissure—the upper, or cuneic lip, representing the homonymous dorsal retinal quadrants; while the lower or lingual lip represents the homonymous ventral quadrants of the retina—while Flechzig and others give to it a wider area, which may extend to the whole of the cuneus, and to the posterior part of the lingual gyrus. Lesions of the cortical centre for vision cause homonymous hemianopsia.

That the functions of the macula lutea so often escape in hemianopsia indicates the existence of some special arrangement of the visual path or cortical centre for this portion of the retina. Henschen's investigations point to the macular centre as being situated in the anterior part of the floor of the calcarine fissure, and to the whole of each macula as being represented on both sides, causing an overlapping of nervous supply in those retinal regions. The researches of Monakow and Bernheimer lead them to think that the macular fibres have a very wide distribution in the external geniculate bodies, and in the occipital cortex, almost any part of which is capable of receiving macular fibres.

The Localisation of the Lesion in Cases of Hemianopsia is a subject of interest, and, in cases of cerebral surgery, it may be of great practical importance.

Lesions of the centre of the *Chiasma* injuring the crossed fibres produce as their characteristic symptom bitemporal hemianopsia, which may be relative at first, beginning, for instance, as a hemiachromatopsia, but later on becoming absolute. In some cases (basal meningitis, periostitis, hyperostosis) the diseased process comes to a standstill, and the bitemporal hemianopsia remains. But the disease generally extends to the uncrossed fibres, ultimately causing complete blindness. Even when the disease is non-progressive, central vision is impaired ; whereas in homonymous hemianopsia the latter is not always affected. Optic atrophy, often commencing on the inner side of the papilla, is nearly always present at some period of the disease. Syphilitic gummata may cause transient recurrent attacks of bitemporal hemianopsia.

In Altitudinal Hemianopsia the lesion must also, as a rule, be at the chiasma, encroaching on it from above or below. Symmetrical cortical lesions might, and optic neuritis sometimes does, produce it.

In Nasal Hemianopsia, too, the lesion must be at the chiasma, and must be so situated in its outer angle as to involve only the fasciculus lateralis of the affected eye. The occurrence of binocular nasal hemianopsia is evidently almost impossible, implying, as it does, symmetrical lesion of the fasciculus lateralis of each tract. According to Henschen, a tumour in the external angle of the chiasma is apt to affect the crossed fibres as well as the uncrossed, and to produce a form of bilateral homonymous hemianopsia. Other symptoms which may be present in lesions of the chiasma are anosmia, paralysis of orbital nerves, and anæsthesia of the conjunctiva and cornea. The causes are : fractures of the body of the sphenoid, cysts, tubercle, tumours, exostoses, distension of the infundibulum of the third ventricle, and, most frequently, tumours of the pituitary body. In the latter case proptosis, discharge of fluid from the nostril, and diabetes may be present. Bitemporal hemianopsia is a very common and early symptom in *Acromegaly*, a disease which is associated with enlargement of the pituitary body.

In Homonymous Hemianopsia—the commonest form of the symptom—localisation of the lesion is a more difficult matter than in any of the other forms; for here the disease cannot be situated at the chiasma, but may be in the optic tract, or in the visual centre, or anywhere in the lengthened course of the visual path which connects these two parts.

Can we distinguish a complete and absolute hemianopsia, due to a lesion confined to the occipital lobe, from a similar defect in the field, due to a lesion in the optic radiations, internal capsule, pulvinar, or optic tract? We may conclude that the hemianopsia depends upon an occipital lesion, if it be unaccompanied by hemiplegia, motor aphasia, or paralysis of cerebral nerves, as direct symptoms; any or all of these are liable to accompany lesions of the occipital lobe as distant [1] symptoms.

Aphasia, too, occasionally accompanies right cortical hemianopsia (*i.e.*, due to a lesion in the left occipital lobe), although it is not easy to offer a satisfactory explanation of the fact.

A diagnostic symptom of cortical hemianopsia is what is known as negative vision, 'vision nulle,'—that is to say, the patient, though he may be aware of the loss of half of his visual field, has no sensation of darkness in it, and is just as unconscious of the defect as a healthy person is of his blind spot.

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[1] The term "distant symptom" is suggested in preference to those in common use—namely, "indirect symptom" and "pressure symptom." We cannot assume that these symptoms are less the direct result of the lesion than any of the others which are present; and, in many instances at least, it is certain that they cannot be due to pressure. In short, we do not yet know what produces these symptoms,—they may be caused by inhibition,—we only know that they are the result of interference with functions of parts of the brain not involved in the lesion; and the term "distant symptom" conveys this idea—although perhaps not quite grammatically—without committing us to any theory. The corresponding German term is "Fernwirkung."

Cortical hemianopsia may be a distant symptom. Gowers has observed that, at the onset of many attacks of cerebral hæmorrhage, hemianopsia is present as a distant symptom of very fleeting character—so transitory, indeed, that it does not complicate attempts at localisation. Except under this condition, distant hemianopsia seems to be rare—a fact which enhances the localising value of the symptom.

Cortical hemianopsia may be incomplete, the homonymous quadrant only of each field being wanting, if the lesion be confined to the upper or to the lower lips of the calcarine fissure (p. 680).

In cortical lesions the hemianopsia is usually absolute. But the lesion may be such as to destroy only the colour-sense, without reaching those for form and light. Again, the form-sense may be lost in the half field along with the colour-sense, while only the light-sense is retained. Furthermore, cases of hemianopsia are on record in which, in part of the defect, both the colour and form senses were absent, but the light-sense present, while in the remainder of the defect all three visual perceptions were lost.

It is generally held that all lesions of the *Optic Radiation* cause homonymous hemianopsia. But Henschen believes that only a small portion of the radiation can be regarded as visual fibres, while Vialet's investigations seem to show that the visual path includes the whole of the optic radiations. A lesion here would be distinguished from one in the cortical centre by the possibility of hallucinations of vision occurring in the former and not in the latter; and further, there would not be 'vision nulle' in the hemianopic defects from lesion in the optic radiations. Lesions of the retro-lenticular portion of the posterior limb of the *Internal Capsule* are still believed by some to cause hemianopsia and hemianæsthesia of the opposite side of the body; but analysis of clinical cases affords no support to this view, for there are no recorded cases which furnish any definite evidence in this respect. Yet, anatomically, fibres have been traced from the occipital cortex through the optic radiations and internal capsule to the basal ganglia. The fibres passing through the internal capsule from the external geniculate body may be reflex fibres simply, while the visual path may go some other way from the external geniculate body to the optic radiation.

The symptoms due to lesion of the *Pulvinar, and External Geniculate Body* in addition to hemianopsia, and which serve to distinguish the latter as being due to a lesion there, have not as yet been ascertained, the clinical evidence being indefinite. In lesions confined to the pulvinar, two typical symptoms occur—viz., hemianopsia and athetosis—and sometimes hemianæsthesia may be present.

Hemianopsia from lesions of the *Optic Tract* is characterised by the absence of such symptoms as mind-blindness, word-blindness, etc., which are apt to occur in cortical affections, and by the presence, probably, of other symptoms pointing to a basal lesion. The defects in the fields may be relative (hemiachromatopsia) or incomplete (only homonymous quadrants being lost). Lesions of the optic tract are, of course, apt to implicate the crus cerebri, but do not necessarily do so; and then there would be hemiplegia of the opposite side of the body associated with the hemianopsia. Symptoms may also be caused by implication of cranial nerves, especially of those which supply the orbital muscles.

Atrophy of the optic nerve, or neuritis, according to the nature of the lesion, are frequently present.

A sign which sometimes enables us to localise a lesion in the optic tract, is the Hemianopic Pupil (Wernicke's pupil-symptom). Illumination of the amaurotic half of the retina produces a more sluggish reaction than when the light is thrown on the sound side, because the lesion is on the distal side of the corpora quadrigemina, and, consequently, the impulse cannot pass on to the centre for the third nerve. It must be stated that some observers deny the occurrence of the hemianopic pupil: on the other hand, many observers have obtained the symptom. A great obstacle in observing it lies in the difficulty of concentrating the light on the blind side of the retina, without allowing it to fall on the good side. If present, this is a valuable sign; but its absence is not decisive, owing to the difficulty of obtaining it.

Wilbrand has proposed an aid in deciding whether the seat of lesion in a case of homonymous hemianopsia is above the primary optic centres (*i.e.*, in the optic radiation or cortex), or in the optic tract. He terms this the Hemianopic Prism Phenomenon, and states that he has found it of practical clinical value. The patient faces a black wall on which a small white mark is made. One eye is closed with a bandage, and the patient is directed to look at the mark with the other eye. A prism of about 12° or 14° is brought suddenly before the eye, its base being so directed that the retinal image of the white spot may be thrown on the half of the retina which does not see (*e.g.*, if the experiment be performed with the right eye, in a case of right homonymous hemianopsia, the inner half of the retina being blind, the prism must be placed opposite the eye with its base inwards). At the same moment the surgeon has to observe whether or not the eye makes such a movement as would tend to bring the retinal image again on the macula lutea (*e.g.*, in the example above chosen the motion would be outwards); and, again, whether or not at the moment of rapid removal of the prism the eye returns to its former position. The prism must be brought rapidly before the eye, in order that the patient may not be able to observe the path of the moving retinal image from the macula lutea towards the boundary line between the seeing and blind halves of the retina. Those cases in which the boundary line is at or close to the macula lutea are the most favourable for the experiment. If a compensatory movement of the eye take place when the prism is held before it, then the path through the optic tract to the nuclear oculo-motor centres is free, and the lesion must be situated above these centres, in the optic radiations or cortex. On the other hand, if there be no compensatory motion, the path for the movements of the eye from the retina to the nuclear centres must be interrupted. The explanation of this phenomenon is very similar to that of the hemianopic pupil symptom. Although the motions of the eye for the purpose of fixing visual objects are not, strictly speaking, reflex motions, yet, in each individual they to a great extent become so by long usage, and are controlled mainly by the lower, rather than by the cortical centres. Hence, so long as the path for these motions to the nuclear centre is uninterrupted, if the retinal image of the visual object be thrown by a prism on a non-seeing part of the retina, the necessary compensatory motion of the eye will be made to bring the image again on the macula lutea.

The Forms of Diseased Process causing a Lesion of the Optic Tract are: syphilitic gummata and syphilitic meningitis; new growths, including tubercle; softening and hæmorrhage are rare. Tumours of the optic thalamus, lenticular nucleus, or temporo-sphenoidal lobe may also injure the tract by extension or pressure.

The Prognosis for recovery of vision in the defective halves of the fields depends, of course, upon the nature of the lesion. But recovery is rare, especially in the most common class of cases—those, namely, which are due to cerebral apoplexy.

In Right Homonymous Hemianopsia, wherever the position of the lesion may be, a greater difficulty in reading is experienced than in left hemianopsia. This is partly due to the fact that we read from left to right; and that, owing to the defect being on the right side, the word immediately following that at which the patient is looking cannot be seen at the same moment. Knies offers another explanation, namely, that, owing to the right-sided defect, there is loss of the fine co-ordinated movements of the eyes to the right.

Alexia (*a, priv.*; λέξις, *speech*), or **Word-Blindness**, is the term given by Kussmaul to an inability to understand written or printed characters, although they and other small objects can be distinctly seen. Other visual objects are named with ease (no visual aphasia). The patient can express his ideas in writing, or write from dictation, yet cannot understand what he has just written, nor can he copy written or printed words. He understands the meaning of spoken words, and the use of all objects around him (no mind-blindness). He can generally recognise individual letters with some difficulty. This is 'pure word-blindness,' or 'subcortical alexia.' When combined with inability to write spontaneously or from dictation, it is known as 'cortical alexia' (Wernicke). The condition has been occasionally complicated with hemianopsia. In those cases where an autopsy was obtained the lesion was found in the left occipital lobe. Word-blindness with agraphia or cortical alexia is due, according to Dejerine and Wernicke, to a lesion in the centre for visual memory for words, which, in right-handed people, is the left angular gyrus, and inferior parietal lobule.

Visual Aphasia consists in inability to name objects seen, the use of which is known. The objects can be named, if the patient be allowed to feel them even with his eyes closed. A few cases of this affection have been recorded, and in all there was right homonymous hemianopsia. Alexia and agraphia sometimes coexisted.

Dyslexia.—This symptom was first described by Berlin. In a wide sense it belongs to the aphasic group. It consists in a want of power on the patient's part to read more than a very few—four or five—words consecutively, either aloud or to himself. The difficulty is not caused by dimness of sight, nor by pain in the eye or head, but simply by an unconquerable feeling of dislike or disgust, due to the mental effort. After a few words which can be well understood have been read, the book is pushed away, and the head drawn backwards and turned aside; and then in a moment or two the patient may be tempted to repeat the effort, but with the same result after a very few words have been read. The symptom comes on suddenly, and has been usually the first sign of the presence of cerebral disease. Although in most of the cases the dyslexia disappeared in the course of a few weeks, either permanently or to recur later on, yet other symptoms soon followed its first onset, such as headache, giddiness, aphasia, hemianopsia, paralysis of the tongue, hemianæsthesia, hemiplegia, twitching of the facial muscles, etc. All the recorded cases had a fatal termination. The lesion was situated, in all but one of those cases where an autopsy was obtained, in the neighbourhood of Broca's lobe. In one case the left hemisphere was normal, while the right hemisphere was extensively diseased.

Amnestic Colour-Blindness is a symptom which is most probably due to a lesion in the occipital lobe, interrupting the paths between the centre for vision and the speech centre. It has always been accompanied by right homonymous hemianopsia. In this condition the patient sees colours and can recognise them, and he can perform Holmgren's tests, but he is unable to name each colour.

Visual Hallucinations may occur in cases of homonymous hemianopsia in the blind side of the field only, being due to irritation of the visual-memory centre. Homonymous hemianopic hallucinations, persisting for years without hemianopsia, have also been observed. Visual hallucinations also occur very occasionally in connection with glaucoma.

Hallucinations differ from illusions in that the former are completely subjective, while the latter are perverted sensory impressions.

Mind-Blindness, also called **Optic Amnesia,** is a symptom first observed by Munk in his experiments upon animals. It consists in the loss of power of recognising objects, while the power of seeing them continues. A whip is seen by the animal, but inspires no terror; a tempting morsel is seen, but excites no desire. The symptom was caused by destruction of a region situated chiefly in the posterior division of the second external convolution of the dog's brain. It has also been observed in man. The patient fails to recognise the most familiar objects by sight. In one case the patient could not recognise his wife until she spoke. There are two forms of mind-blindness—the cortical and the transcortical. In the former, the lesion is in the centre for memory; and the patient has lost the power of visual imagination, and cannot describe visual objects from memory. In the latter, the connecting path between the centre for vision and the visual memory centre is interrupted, and the patient, though he can describe an object from memory, is unable to recognise it when looking at it. Hemianopsia is present in the majority of cases of mind-blindness; and colour-blindness, complete or hemianopic, is not unusual. The lesion has been found in the occipital lobe, sometimes involving the parietal convolutions. It usually consists in hæmorrhage or softening, and the symptom is consequently sudden in its onset; but it also occurs from tumours. Exhausting illnesses, by reducing the mental energy, may produce a condition of mind-blindness.

Some authors localise the centre for visual memory in the angular gyrus, whilst others take for it the whole of the occipital lobe, except the cuneus and its neighbourhood.

The localising value of orbital paralyses has been explained (p. 597).

PART II.

OCULAR DISEASES AND SYMPTOMS LIABLE TO ACCOMPANY CERTAIN DIFFUSE ORGANIC DISEASES OF THE BRAIN.

There are organic diseases of the brain which are not focal, and which, as they attack extensive regions of the brain substance, may be called diffuse. Under the same heading may be placed some diseased cerebral states which we cannot doubt are organic, although their pathology is as yet unascertained. It is proposed here to describe the points of ophthalmological interest which belong to some of these diffuse brain diseases.

Disseminated Sclerosis of the Brain and Spinal Cord.—Central Colour Scotoma is the most usual defect of sight in this disease, and in a few cases absolute central scotoma is present. Irregular defects in the periphery of the fields—sometimes only for colour—or regular concentric contraction may be found. These defects may be in one or in both eyes; they most commonly come on very rapidly, and they may get better, or may, after a time, get quite well. Even complete blindness, lasting as long as several months, may occur; but permanent complete blindness is rare. The ophthalmoscopic appearances do not always coincide with the state of the vision; for with marked defect of sight the fundus oculi may be normal, or the vision may be normal, while the optic papilla looks diseased, or both sight and ophthalmoscopic appearances may be abnormal. The most common ophthalmoscopic change is a not very intense atrophic appearance of the whole surface of the papilla, or its temporal third alone may be affected in this way. But in these latter cases, where the temporal third alone shows atrophy, a central scotoma is not necessarily present, nor are the papillo-macular fasciculi in the nerve diseased. In a very few cases optic neuritis is present. The ophthalmoscopic changes may be in both eyes or in only one. Hemianopsia has not been noted, and therefore the defects of vision are evidently always due to disease in the optic nerve, and not in the chiasma or tract. Uhthoff has shown that in disseminated sclerosis there may be disease in the trunk of the optic nerve, without any abnormal ophthalmoscopic appearances, or defect of sight. Sometimes defects of vision and ophthalmoscopic changes precede all other symptoms by long periods, or they appear in the very early stages of the disease; but more commonly they do not come on until other symptoms have been present for some time.

Isolated paralyses of orbital muscles, nuclear paralysis, and nystagmus are derangements of the oculo-motor apparatus, which are liable to be present in disseminated sclerosis. Marked exterior ophthalmoplegia is rare; but the paralyses of nuclear origin of which there can be no doubt, are loss of conjugate motion to one or other side, and defective power of convergence. Nystagmus is present in about 50 per cent. of the cases, and is either of the ordinary kind or consists merely in nystagmic twitchings, more particularly at the extreme lateral positions of the eyeballs. Very slight twitchings in these extreme positions are of no import, as they occur even in the healthy state. As true nystagmus is an uncommon symptom in other diseases of the general nervous system, it is of value in the diagnosis. Nystagmic twitchings, while they do occur in other general nervous diseases, are more common in disseminated sclerosis than in any other of these diseases.

Disseminated sclerosis in its early stages is apt to be mistaken for hysteria, owing to the presence of such symptoms as transitory loss of power in limbs, aphonia, convulsive seizures, hysterical manner, and so on, and here the eye-symptoms may come to our aid. In hysteria the ophthalmoscopic appearances are normal; the fields of vision, if deranged, are contracted, central scotoma being rare, and when the fields are contracted the colour boundaries often do not recede in their regular order—the field for red, for example, may be wider than that for the other colours. In hysteria, again, it may be found impossible to examine the colour fields at all, all colours being named dark or black ; and finally oculo-motor disturbances rarely occur.

Diffuse Sclerosis of the Brain.—In some rare cases of this disease, headache, vomiting, and double optic neuritis may lead to the diagnosis of cerebral tumour, an error in diagnosis which, with our present knowledge, it is impossible to avoid, unless there be also focal symptoms that would point with certainty to a tumour. The mistake will not often occur, as the cases here indicated are exceedingly rare.

General Paralysis of the Insane.—Derangements of the intrinsic muscles of the eyeball, orbital paralyses, atrophy of the optic disc, and mind-blindness are the eye-symptoms which may be found in this disease.

The Pupil, etc.—The pupils are usually contracted in the early stages, and dilated at later periods. An early symptom is slight inequality in the pupils, with somewhat sluggish reaction of the wider one, and, also at an early period, there is apt to be loss of the pupil-reflex to sensory stimuli. Later on the larger pupil does not react to light at all, while its fellow does so normally, and sight is good. The so-called paradoxical pupil-symptom is an early augury of coming paralysis, and consists in this, that when a strong beam of light is thrown into the eye with the focal illumination, the pupil at first contracts fairly well, then dilates slightly, contracts again, and after a few such oscillations finally dilates widely, although the strong light still shines into the eye. The Argyll Robertson pupil is only found in some cases, and then usually in the late stages, but it does occasionally present itself in the initial stages. Sometimes the pupil is irregular in shape.

Paralyses of Orbital Muscles.—These are of rarer occurrence than paralysis of the pupil; but the third and sixth nerves are occasionally paralysed even in the early stages, and in these stages, too, ptosis, and transient nystagmus and twitchings of the eyelids may be seen.

Optic Atrophy.—This is rare in general paralysis, and is then seen for the most part in the late stages. But it has sometimes come on in a very early period, and has even preceded every other symptom by several years.

Mind-blindness occurs in cases of general paralysis, usually in the advanced stages.

Amaurotic Family Idiocy (Sachs), or **Infantile Cerebral Degeneration with Symmetrical Changes at the Macula Lutea** (Kingdon and Risien Russell).—This disease occurs in children during the first year of life, and most, if not all, of the cases recorded, occurred in Jewish families. Family predisposition is strongly marked, as many as five children in a family of seven having been attacked. The causes which have been assigned are neurotic taint, blood relationship between the parents, and traumatism of the mother during pregnancy. Syphilis does not seem to play any part in the etiology.

The children are born sound and healthy, and continue to be so for some months. They then cease to develop mentally, and idiocy is gradually established. At the same time paresis or paralysis, either flaccid or spastic, of the greater part of the body appears, while the reflexes may be deficient or increased. Hyperacusis is often present. A chief and very early symptom of the disease is loss of sight, ending in absolute blindness, with certain characteristic ophthalmoscopic appearances, and nystagmus and strabismus are sometimes present. A slowly increasing marasmus leads to a fatal termination before the end of the second year, as a rule. Waren Tay first observed the peculiar ophthalmoscopic appearances, and Sachs described the clinical history, general symptoms, and morbid changes in the brain.

The ophthalmoscopic appearances are as follows:—There is at first no change in the optic discs. At the macula lutea in each eye there is a large white spot, rather diffuse, with softened edges, and about twice the size of the optic papilla. In its centre there is a brownish-red, fairly circular spot, which contrasts strongly with the white around it. This central spot, as Tay says, has not the appearance of a hæmorrhage, nor of pigment, but suggests a gap in the white patch through which the healthy structures are seen. In short, the appearance reminds one of that seen in cases of embolism of the central artery of the retina. At a later period, with complete amaurosis, atrophy of the optic nerve is found.

In the brain the diseased appearances consist in degeneration of the pyramidal cells of the cerebral cortex. In the pons and medulla oblongata, degeneration of the pyramidal fibres and of the fillet has been found; and in the spinal cord, degeneration of both the crossed and direct pyramidal tracts was seen. Treacher Collins found œdema of the retina around the yellow spot, and Holden discovered disease of the ganglion cells of the retina similar to that in the cerebral cortex. The normal absence of the ganglion cell layer at the macula lutea, and the fact that it is thickest just around the latter, go far to explain the ophthalmoscopic appearances.

Meningitis.—Inflammation of the cerebral meninges, of whatever form, and whether at the base or on the convexity of the brain, is liable to be accompanied by optic neuritis. When the meningitis is at the base, ocular paralyses, pain or anæsthesia of regions supplied by the fifth nerve, and defects in the fields of vision from pressure on the optic tracts or commissure, may be found.

Acute Tubercular Meningitis.—In a small percentage of the cases of this form of meningitis miliary tubercles in the chorioid are present (p. 405). Optic neuritis is more common than in any other form of meningitis, as are also orbital paralyses, in consequence of the tendency of this form to attack the base of the brain.

Cerebro-Spinal Meningitis.—Eye-symptoms are often present both in the epidemic and sporadic forms of this disease. Swelling of the eyelids, conjunctivitis, and photophobia are frequent, even in the early stages. The pupils may be unequal, contracted, or dilated. There may be ulceration of the cornea, parenchymatous keratitis, or deep purulent infiltrations. Retinitis and plastic irido-chorioiditis, followed by retinal detachment, may be found, or there may be purulent irido-chorioiditis, with purulent infiltration of the vitreous humour, going on to panophthalmitis. If the fundus can be examined, optic neuritis or neuro-retinitis will often be seen, or thrombosis of the central vein, with retinal hæmorrhages. Each epidemic of cerebro-spinal meningitis is apt to be associated with some one of these conditions as its special type of eye-affection. The eye-affections in cerebro-spinal meningitis then are very grave; but some of the cases of irido-chorioiditis do recover, with retention of good sight.

Traumatic Meningitis.—Falls and blows on the head which do not fracture the skull are held by many to be capable of causing meningitis, and occasionally, the inflammatory process, reaching the optic nerve, creeps down it to the optic papilla, where it may be diagnosed with the ophthalmoscope.

Hydrocephalus.—Well-marked papillitis, or neuritic atrophy, is sometimes found in congenital hydrocephalus, or in the hydrocephalus which makes its appearance in infancy; and it would probably be more common, but for the compensation for the increased intracranial pressure, which distension of the sutures and fontanelles must provide. In the acquired hydrocephalus of later life, optic neuritis passing over to optic atrophy is the rule; and such cases may closely simulate an intracranial tumour in all their other symptoms as well. Bitemporal hemianopsia is apt to be present, owing to pressure on the optic commissure by the distended floor of the third ventricle.

Infantile Paralysis.—Hemianopsia has been noted in a very few cases of this affection; and papillitis, with some orbital paralysis, has also been seen, but usually there are no eye-symptoms.

Paralysis Agitans.—In some cases a fine vibratory tremor may be noticed along the margin of the upper lid, especially when the eyes are closed, and the lids will be found to be unusually rigid on an attempt being made at passive opening of them. The slowness of muscular action in other parts does not affect the motions of the eyeballs. If a patient be called on to look in any direction, the eyes are instantly turned, while the head slowly follows them.

Encephalopathia Saturnia.—Even in the milder cases, transient hemianopsia or amaurosis, which may last for several hours, is sometimes met with. There need be no renal disease, and the visual defect must be taken as the result of the lead-poisoning on the brain. In those cases in which acute cerebral disturbance sets in (convulsions, delirium, coma) it is often attended by optic neuritis, with considerable swelling of the disc, and retinal hæmorrhages.

Sometimes the fields are contracted without ophthalmoscopic appearances, as in hysteria. The pupils may be unequal. As headache, vomiting, and convulsions are symptoms of the more serious cases of lead-poisoning, it is evident that when intense optic neuritis is added, the diagnosis between this disease and cerebral tumour has to be considered. The characteristic blue line on the gums, anæmia, colic, constipation, drop wrist, and lead in the urine, are the aids to the diagnosis, along with the previous history, including the patient's occupation.

Epilepsy.—A visual aura is more common than any other special sense aura in idiopathic epilepsy. It may take the form of subjective sensations of lights, colour, flames, megalopsia or micropsia, etc.; or visual hallucinations may occur; or there may be simple homonymous hemianopsia. Where epilepsy is due to organic brain disease a visual aura, occurring always in homonymous sides of the fields, is important, as indicating the occipital lobe as the region of the brain in which the discharge originates. At the onset of an epileptic fit, there is often conjugate lateral deviation of the eyes to the opposite side of the body from that on which the convulsions commence, with rotation of the head in the same direction, while subsequently the eyes may suddenly be turned in the opposite direction. The condition of the pupils vary, often even in one and the same fit. At the onset they are usually normal or contracted; but during the tonic spasm they become dilated, and remain so until consciousness returns. The pupillary light-reflex is lost—a point of importance in the diagnosis of a true epileptic fit from an hysterical attack, in which latter it is retained. After a fit, rapid changes in the size of the pupil may sometimes be seen, and these are valuable as evidence of the fit having been a genuine one. The ophthalmoscopic appearances during a fit vary in different cases. In some they are normal, in others there is marked pallor of the disc and contraction of the blood-vessels, and, again, in others the papilla is hyperæmic and the retinal veins enlarged. Optic neuritis and optic atrophy do not belong to epilepsy; and if found they can be regarded only as complications. Between attacks the fundus may be normal; but it is not unusual to find a high degree of hyperæmia of the retina and papilla, which may continue for some days or hours, or may even become chronic. The fields of vision after a fit, and sometimes as a permanent state, are concentrically contracted; or there may be colour-blindness, and the central acuteness of vision may be reduced. The state of the fields is a valuable aid in the detection of simulation. Transitory amblyopia (migraine, scotoma, etc.) is more frequent in connection with epilepsy than under any other condition. It may precede the true attack by years, or it may occur with, or for an hour or so before, the fits, or it may be substituted for them. Inasmuch as this transitory amblyopia is often attended by disturbances in speech, in the intelligence, or by passing paralysis, and as both eyes are usually attacked by it, frequently in the form of homonymous hemianopsia, it is obvious that its cause resides in the visual cortex. Occasionally the blindness is monocular, and must then be referred to disturbance in the circulation of the retina or optic nerve. It is held by some authorities that, given a predisposition to epilepsy, irregularities in refraction may at times prove the exciting cause of the disease; and that cases of epilepsy occur, in which the attack is induced by the undue strain put upon the muscular apparatus of the eye by reason of an abnormality of refraction. They also hold that, if correcting glasses be worn by these patients at a sufficiently early period, the fits will cease, or at least in a considerable proportion of the cases. Further investigations on this subject are required, especially as concerns the permanence of cures.

Chorea.—It is probable, that in some cases, at least, of this affection, cerebral embolism may be taken as the cause. Several instances of embolism of retinal vessels have been seen in immediate connection with the onset of chorea.

In chorea the eyes participate in the irregular jerky motions, and the spasm may be so unequal in the two eyes as to cause brief diplopia; although, not being constant, it is little heeded by the patients, and is rarely mentioned by them.

PART III.

OCULAR DISEASES AND SYMPTOMS LIABLE TO ACCOMPANY CERTAIN DISEASES AND INJURIES OF THE SPINAL CORD.

Tabes Dorsalis.—Amongst the ocular complications to be found in this disease, *Atrophy of the Optic Nerve* is the most serious. It occurs in about 20 per cent. of the cases, and commences more frequently in the pre-ataxic period than subsequently. Rarely it is the first symptom, preceding all spinal symptoms by from two to twenty years, and it does sometimes commence in the later stages of locomotor ataxy. Coming on in the pre-ataxic stage, optic atrophy seems very often to have, as it were, a favourable influence on the spinal disease, the spinal symptoms already existing becoming ameliorated or disappearing, while the further progress of the disease is retarded or averted. It is indeed rare for tabetic patients who go blind at an early stage of the disease to become ataxic later; but if the ataxy be once well marked, it does not improve with a subsequent development of optic atrophy. It sometimes occurs that the onset of optic atrophy in one eye precedes that in the other by a long interval, even by many years; but usually the eyes are affected simultaneously, or with a very short interval. The relation between the optic atrophy and the spinal disease is not as yet well understood. The atrophy is probably merely a manifestation of a diseased process in the optic nerve, similar to that which attacks the posterior columns of the cord.

Paralysis and Ataxy of the Orbital Muscles.—Paralyses of orbital muscles in locomotor ataxy occur in about 30 per cent. of the cases. They usually appear in the pre-ataxic stage, and even as an initial symptom, and are of two kinds—namely, the transient paralysis, which lasts a few days or weeks, and may recur; and the permanent paralysis of one or two muscles. Diplopia is produced by these paralyses, and is often the symptom which first induces the patient to see his doctor. The sixth nerve is the one most commonly paralysed; but the third nerve is also often paralysed, including the branch to the levator palpebræ, with resulting ptosis. Loss of power of convergence is often present in commencing tabes, and double exterior ophthalmoplegia, as well as double sixth-nerve paralysis, is sometimes seen; and there can be no doubt but that all these three conditions, and probably also some of the other oculo-motor disturbances in tabes, are often of nuclear origin. But the orbital nerves may, it is found, undergo atrophy without their nuclei being altered, and probably, therefore, some of the ocular paralyses here are due to peripheral neuritis.

Ocular ataxy is another not infrequent symptom in tabes. It is sometimes erroneously called nystagmus; but nystagmus is a constant oscillatory motion of the eyeballs, both while the eyes are at rest, and when they are looking at an object, and is extremely rare in tabes. In ocular ataxy, so long as the eyes are at rest, there is no oscillation or twitching; but as soon as an object is carefully looked at, and especially if followed when in motion, and more particularly at the end of the latter, a slight twitching of the eyeballs is seen. It may be found in any stage of tabes.

Pupillary Alterations.—Myosis is the usual state of the pupil in tabes, and is held to be due to paralysis of the pupil-dilating fibres from disease in the front part of the aqueduct of Sylvius. The myosis is often extreme, or "pin-hole," as it is then termed; yet the pupil may react to light and on convergence. The pupil may be of normal size in tabes; but mydriasis, except as part of a third-nerve paralysis, is rare. Again, both in the early and later stages the pupils may be of different sizes.

The Argyll Robertson pupil is an important symptom of tabes. It consists in this, that the pupil, although as a rule contracted, does not respond to the stimulus of light by further contraction, or, if so, but slightly, yet does become more contracted on convergence of the visual axes (or on accommodation). Myosis need not necessarily be present with the Argyll Robertson pupil; the pupil may be of normal size or dilated. The symptom is one of those most regularly found in tabes. It is often an early or initial symptom, and it continues through all the stages of the disease. It is occasionally present in one eye only, and is sometimes quite wanting.

Neither the Argyll Robertson pupil nor primary optic atrophy occurs in peripheral neuritis, a disease which is liable to be sometimes mistaken for tabes.

Paralysis of Accommodation without paralysis of the sphincter iridis is a rare symptom in tabes. It is more common in the late than in the early stages.

Narrowing of the Palpebral Fissure, due to a slight drooping of the eyelids, hardly to be called ptosis, sometimes occurs in tabes along with the myosis. It is held to be due to paralysis of the sympathetic (sympathetic ptosis), is usually binocular, and the frequency of its occurrence increases as the disease advances.

Twitchings in the Orbicularis Muscle for some Moments after Closure of the Eyelids may sometimes be observed in tabes. Similar twitchings may occasionally be seen in some other nervous diseases, and even in health, but less well marked. Probably their marked character in tabes is due to very slight facial paralysis, and the consequent imperfect power of closing the eyelids.

Hereditary Ataxy (Friedreich's Disease) has few eye-symptoms, a fact of some diagnostic importance. Ataxic nystagmus, as Friedreich pointed out, is the only one which occurs with any constancy. Optic atrophy is of such rare occurrence in the disease, that it can hardly be reckoned as one of its symptoms. Paralyses of orbital muscles do not occur, nor does any pupil-symptom.

Myelitis.—Apart from the inflammation of its meninges (cerebro-spinal meningitis), of which mention has already been made (p. 695), acute inflammation of the cord may be associated with optic neuritis. The optic nerve seems usually to become inflamed before the spinal cord, but the myelitis may precede the optic neuritis, or optic nerve and spinal cord may be simultaneously attacked. The relation of the optic neuritis and myelitis to each other is, doubtless, nothing more than that each is a manifestation of the presence in the system of one and the same toxic influence, whatever it may be. Rheumatism, epidemic influenza, and syphilis, are amongst the causes assigned in some cases, while in others no cause could be assigned. If the cervical portion of the cord is inflamed, pupillary symptoms—irritation mydriasis or paralytic myosis—are apt to be present.

Syringomyelia and **Morvan's Disease.**—One eye-symptom is common to both of these diseases (which are, indeed, held by many to be one and the same disease)—namely, a concentric contraction of the field of vision without ophthalmoscopic changes. It is not quite certain whether this abnormality of the field is due, at least sometimes, to attendant hysteria, or is always a symptom of the organic disease as such. Inequality of the pupils has sometimes been noted.

Myotonia Congenita (Thomson's Disease).—In some cases of this rare disease the external musculature of the eyes affords symptoms, although the intrinsic muscles are never disordered. The opening and closing of the eyelids may be difficult—they cannot be closed or opened at one stroke, successive jerky motions being required to effect closure or opening. As in Graves' disease, when the eyes are open the upper lid is apt to be retracted, and the upper lid does not readily follow the downward motions of the eyeball. Transitory amblyopia, or even amaurosis, has been noted in some cases.

Acute Ascending Paralysis (Landry's Disease).—Eye-symptoms are rare in this disease, but there may be paralysis of some of the orbital muscles, paralysis of accommodation, mydriasis, or loss of the light-reflex.

Injuries of the Spinal Cord.—The condition which used to be known as railway spine, but which is now better styled traumatic neurosis, and is due to mental shock rather than to organic lesions of the brain and spinal cord, is accompanied frequently by certain functional eye-symptoms, of which the chief one is a contraction of the field of vision similar to that found in some cases of hysteria. In those much rarer cases of organic injury to the cord, or of myelitis, or of hæmorrhage in, or inflammation of, its membranes, following on railway and other accidents, organic eye-disease seldom results, although optic neuritis and optic atrophy were at one time held to be frequent consequences of these injuries. If the lesion be in the lower cervical region of the cord, the pupils are apt to be contracted from sympathetic paralysis.

Part IV.

NERVOUS AMBLYOPIA, OR NERVOUS ASTHENOPIA.

We find Nervous Amblyopia, or Nervous Asthenopia, for the most part in connection with three functional disorders of the nervous system—namely, Neurasthenia, Hysteria, and Traumatic Neurosis. Many observers, it is true, hold that these three conditions ought to be regarded and treated of as hysteria, that the term neurasthenia is quite superfluous, while traumatic neurosis is merely hysteria caused by shock.

This is not the place to enter into a discussion on this question; and it need only be said that while these various states of the nervous system are admitted on all hands to have much in common, and also to merge insensibly into each other, yet typical cases of each are sufficiently differentiated to make it justifiable and convenient, for the present to retain all three in our minds, as separate clinical entities.

It may in general be stated that neurasthenia is abnormal susceptibility of the nervous system to fatigue from mental or bodily exertion; while in hysteria the symptoms depend upon idea, the essence of hysterical conditions being that ideas too easily excite abnormal changes in the organism.

The defects of vision which accompany these disorders are, like all their other symptoms, purely functional—*i.e.*, they do not depend on any organic disease in the retina, or other portions of the visual apparatus, but merely upon derangement of the functions of these parts. Consequently, there are no ophthalmoscopic changes in the fundus oculi.

In the following, the derangements of vision most liable to be found in each condition will be pointed out, but here it is desirable in the first instance to state them in a general way. Complete blindness of one or both eyes may be found, but is rare; a diminished, but fluctuating, acuteness of vision is more common, the effort or desire to see well being often the signal for the acuteness of vision to fall, and objects disappear from sight if looked at long. Attacks of defective sight, too, may come on suddenly without any provocation, accompanied by positive scotomata, and may last for some minutes. But the most remarkable, important, and characteristic symptom is concentric contraction of the fields of vision. It is almost always necessary, in order to ascertain the presence of this symptom, to examine the fields with the perimeter—no rougher method will answer—and it is important to use a test-object of not more than 5 mm.

square. Concentric contraction of the fields is, we know, a symptom in optic atrophy and in glaucoma; but, while in those diseases the contraction usually advances with more or less deep re-entering angles directed towards the fixation point, in nervous amblyopia the contraction is about equal in degree in each meridian, and hence the seeing portion of the field which is left presents a somewhat circular shape. This shape of the field with normal ophthalmoscopic appearances is pathognomonic of the condition. The contraction may be but slight, or it may approach to within 10° or 5° of the fixation point. It is almost invariably present in both eyes, but it is often much more marked in one eye than in the other.

Associated sometimes with this concentric contraction, and sometimes without it, is a phenomenon known as the fatigue field. It consists in this, that if the test-object be brought from the periphery towards the fixation point in each meridian successively, the outside limit of the field comes nearer to the fixation point on each successive meridian examined, without regard to the part of the field in which the examination is commenced. Or, if the test-object be brought in the horizontal meridian from the periphery on, say, the temporal side across the field until it disappears on the nasal side, and the points of entrance and of exit noted, and the object be immediately carried back on the same meridian until it disappears on the nasal side, and the entrance and exit again noted, and this manœuvre repeated five or six times; should fatigue be present, it will be shown by the points of entrance nd exit coming nearer and nearer to the fixation point on ach journey—in short, the field is becoming more and more ntracted. This method of taking the field in these cases s been proposed by Wilbrand, and is useful, too, as showing hether at the beginning there is any concentric contraction the field. These two modes of examination are actically the same; and the reason for the form of fields they are intended to bring out is, that the longer in each case the examination is continued, the more fatigued does the nervous visual apparatus (be it cerebral centre, or retina, or both) become, and this exhaustion is most marked in the periphery of the field. In the normal state, the boundary of the field is not much affected by the length of the examination.

In addition to contraction of the visual field, inversion of the colour fields is often present, the field for red being the largest. (See p. 44.)

Ring-form and island-like defects in various parts of the field, which come and go, are recognised as functional defects, and cannot be confused with the continuing central scotoma of toxic amblyopia due to disease in the papillo-macular fibres. In addition to the defective sight, or contraction of the fields, or fleeting scotomata, there are often other eye-symptoms present, such as weakness of accommodation, or of the internal recti, or some derangement of the fifth or facial nerves.

While functional derangements of vision, as distinguished from those due to organic disease, are what are here under consideration, yet it is very necessary to mention that visual defects due to organic disease may sometimes be aggravated by functional blindness. In tabes with optic atrophy, for instance, the contraction of the field may become suddenly increased with the occurrence of some mental worry or intercurrent general illness, and become restored again to its former dimensions with the return to a calmer state of mind or to improved health. In homonymous hemianopsia there is often a peripheral contraction in the seeing side of the field, which can only be due to diminished functional activity in the opposite side of the brain from that in which the disease is situated.

In the three disorders of the nervous system mentioned, the symptoms may, in a given case, remain confined to the nerves which are associated with the various functions of the eye ; but this is rare. It is more common to find also symptoms provided by the derangement of functions in other parts of the nervous system.

Nervous Amblyopia in Neurasthenia.—School-children and those of that age are very liable to become neurasthenic. They are brought to the physician with the complaints that the sight is confused, that print disappears as they look at it, that reading causes the eyes to smart and run over water, and that it brings on headache. If the patient be required to read aloud he soon stops, complaining that the words are running into each other, and the book is then brought closer to the eyes ; then a few more words are read, and the book is brought still closer, until, finally, it is nearly in contact with the nose ; and then further attempts to see are made by twisting the head about, turning the book towards the light, frowning, and so on. Obviously what causes this difficulty in reading is a rapid exhaustion of the accommodation. Insufficiency of the internal recti is also often present, and would contribute to the difficulty of use for near work. The eyes are often emmetropic, and the amplitude of accommodation is normal. Examination of the fields will often discover them to be concentrically contracted, and the fatigue field, too, is frequently present. With these asthenic symptoms there are often symptoms of exalted sensibility of the visual apparatus, such as photopsiæ (bright spots, coloured balls, glittering surfaces, etc., before the eyes), a prolonged continuance of the after-images of objects, increased sensitiveness to daylight, and still more so to artificial light, and visual hallucinations (heads, animals, passing shadows, etc.). In the neurasthenia of school-children eye-symptoms often predominate, but other nervous symptoms are nearly always present, such as hallucinations of hearing, states of uncalled-for joyous excitement, or of mental depression, or of irritability of temper. Vertigo, a tendency to weep, some loss of memory, and insomnia may all, or any, of them be present. The patellar reflex is usually increased. Patches of diminished sensation may be found here and there over the surface of the body, although completely anæsthetic patches, or hemianæsthesia, are rare.

In school-children complaints of difficulty in reading suggest malingering in many instances, but it is not wise to adopt this view without good grounds for it. An examination of the fields may set the question at rest, for neither the concentrically contracted field nor the fatigue field can be malingered.

The neurasthenia of adults manifests itself, so far as eye-symptoms are concerned, less in the use for near work than is the case with school-children. In them, moreover, the contraction of the fields is usually slight, while the fatigue field is well marked. These patients come complaining of unpleasant and painful sensations in and around the eye, such as creeping sensations and boring pains in the orbit, stabbings in the eyeball, a sensation as if the eye were turned round in the head, uneasy feelings attending the motions of the globe. The eye may be very painful on pressure at some one spot without apparent cause; and there are often uncomfortable sensations of cold, burning, or dryness under the lids. If there be an error of refraction it is difficult to find glasses with which the patient will be content, the bridge and wings of the frames annoying them with their slight pressure, while the reflection of light from the margins of the eye-pieces causes dazzling. The patients are very sensitive to any bright light. The central acuteness of vision is usually normal, but use of the eyes for near work causes headache, often in the form of a hammering in the temples, or a sensation of pressure on the vertex.

Treatment.—Tinted protection spectacles. Abstinence from use of the eyes for near work. A general tonic treatment, including cold sponge baths when they can be borne, bracing air, plenty of exercise in the open air short of fatigue, early hours, and easily digested diet. As regards drugs, strychnine and iron are those from which most can be expected.

Nervous Amblyopia in Hysteria.—Nervous amblyopia, or nervous asthenopia, in hysteria is often very similar to that in the neurasthenia of school-children, except that the difficulty for near work is even greater. Tonic blepharospasm and partial paralysis of orbital muscles may accompany it. The field of vision is commonly more contracted in one eye than in the other, or the contraction may be very marked in one field, while the other field is normal or nearly so. In neurasthenia the contraction is usually about equal in each eye. Inversion of the colour fields is often present in hysterical amblyopia. Orientation is rendered more difficult by the hysterical than by the neurasthenic field. A high degree of blindness or even complete amaurosis may attack a neurasthenic school-child for a few minutes; but in hysteria such attacks, which may occur in both eyes, but are usually confined to one eye, are likely to last for weeks, or months, or longer. In the amblyopia of hysteria, we may find, that an eye, which cannot see moderately sized type, is enabled to do so by placing any plane glass as spectacles before the eye. Such an occurrence by no means proves that the patient is malingering; it shows, rather, that the psychical inhibition to the function of sight in the eye has been withdrawn by the suggestion provided by the spectacles.

With monocular amblyopia, or amaurosis, there is usually hemianæsthesia of the same side of the body as the blind eye; or, if there be merely contraction of the fields, there is often hemianæsthesia of the side of the most contracted field.

The pupils vary much in these cases, and even in one and the same case from time to time. They may be normal, or wide and immovable, contracted, or of different size in each eye.

Nervous Amblyopia in Traumatic Neurosis. In traumatic neurosis, one of the most important and most constant of the symptoms is concentric contraction of the field of vision. Yet it is often absent, and, when present, is not always sufficiently typical in form to enable it to be utilised in the diagnosis. It is not often so pronounced as to interfere with orientation, and must be sought for with the perimeter to determine its presence. The boundaries for the colour-fields are affected even more than that for white, and consequently the tests for these boundaries may discover the contraction more readily than examination of the boundary for white. The colour boundaries are often inverted, but colour-blindness is seldom present. The defect in the field is usually to be found in both eyes, and if there be hemianæsthesia it is on the side of the most contracted field. It is an important fact that the contraction of the field may be the only derangement of sensation, either special or general. The contraction is liable to continue for months or years, and to become more marked for a time, as the result of any passing mental disturbance. The fatigue field, too, is present in some cases of traumatic neurosis.

As regards other ocular symptoms in traumatic neurosis: the pupil-reflex is usually normal, but is occasionally wanting, and a difference in size of the pupils may sometimes be noted; paralyses of orbital muscles are rare, but insufficiency of the internal recti is not uncommon; sensations of sparks, colours, and waviness before the eyes are sometimes complained of; photophobia, and sensations of dazzling with their resulting blepharospasm, may be present.

It is not desirable to rest content with one examination of the field of vision which may prove negative in its result, for it is only shown thereby that on that particular occasion the field was normal. At a later period a defect may be found.

PART V.

VARIOUS FORMS OF AMBLYOPIA.

Transitory Hemianopsia, or **Scintillating Scotoma.**—This affection is characterised by (1) symmetrical defects in the fields of vision, usually of the hemianopic type, and (2) vibrating or scintillating luminous sensations, which after a short time disappear, and are followed by an attack of (3) migraine. In fact, the visual troubles belong to the symptoms of migraine.

The scintillations and defects in the fields, either of which may occur first, commence over a small area, generally near the centre of the field, and gradually widen out; the flashing increases in intensity, and often assumes a zigzag shape, like fortifications, at the periphery of the defect in the field. And this defect may exist as symmetrical scotomata, complete or partial homonymous hemianopsia, or even altitudinal hemianopsia. In some cases the scintillation may be absent, while in others the attack of migraine does not follow. The ocular symptoms, which last for a period varying from a few minutes to half an hour, are not accompanied by any changes in the fundus oculi, and always end in complete recovery. Vertigo, nausea, or sickness, and even slight aphasia sometimes accompany the headache.

This affection occurs most frequently in intellectually active individuals; fatigue, long reading, and hunger have been known to bring on attacks. The symptoms are most probably due to disturbances in the cerebral circulation.

Treatment should be directed to the cause of the migraine. Lying with the head low, or stimulation of the circulation by wine or nitro-glycerine sometimes cuts short an attack.

Congenital Amblyopia.—This condition is not very uncommon. Ophthalmologists, in the course of their practice, come across people in whom the vision of both eyes is below the normal standard, even with perfect correction of any error in refraction, and who declare that they never have seen better, and that their sight is not getting worse. Still more common is congenital amblyopia in one eye. As a rule the field of vision and the colour-vision are normal, but cases are seen in which there is contraction of the field, with defective colour-sight.

The *Ophthalmoscopic Appearances* are normal.

Reflex Amblyopia is said to have been observed, and chiefly in connection with irritation of the fifth pair, especially its dental branches. Carious molar teeth are reputed to be its frequent cause, usually with severe toothache, but sometimes without it. The defect of vision may be confined to the side of the carious tooth, and is nearly always most marked on that side. It is said that it may be of extreme degree, vision being reduced even to the merest perception of light.

More generally recognised than amblyopia, as the result of toothache, are: hyperæsthesia of the retina, photophobia, subjective sensations of light, and diminution in the amplitude of accommodation.

All these symptoms, even amblyopia of the severest type, disappear when the dental affection is relieved.

Many cases are on record in which wounds of the supra-orbital nerve were looked on as the cause of amblyopia or of amaurosis; but it is by no means certain that an ophthalmoscopic examination would not have afforded another explanation in many of these cases. Yet even nowadays many hold that wounds of the supra-orbital region can produce amblyopia, as cases are said to have been cured by division of the nerve involved in a cicatrix that was tender on pressure.

Sympathetic Irritation (p. 373) is to be included under this heading. It is seen in the sound eye in some cases of cyclitis, and must not be confounded with sympathetic ophthalmitis, which comes about in quite a different way. Its symptoms are: diminution of the amplitude of accommodation, asthenopia, hyperæsthesia of the retina, lacrimation, and subjective appearances of light.

Removal of the exciting eye, if otherwise indicated, always relieves sympathetic irritation; but, where this is not admissible, the dark room, atropine, dry cupping at the temple, with bromide of potassium internally, may be employed.

The *Ophthalmoscopic Appearances* in reflex amblyopia are normal.

Night-Blindness.—This is a well-recognised symptom of the disease known as Retinitis Pigmentosa (p. 520). An instance of congenital night-blindness in five members of a family of ten children without ophthalmoscopic signs, has come under the notice of one of us; and Richter, quoted by Lawrence, observed a similar instance.

But the condition to be considered here is Acute, or Idiopathic, Night-blindness.

The patients can see well in good daylight; but on a very dull day, or in the dusk of evening, or by indifferent artificial light, their vision sinks very much more than that of persons with normal eyes. They are then unable to see small objects, which are quite plain to other people, and in a still worse light they fail even to recognise large objects visible to every one else. This peculiar visual defect is due to imperfect adaptation power of the retina, and not to defective light-sense, as is sometimes stated.

Conjunctivitis and xerosis of the conjunctiva are often present in acute night-blindness (p. 182). Some observers have found micrococci and bacilli in the conjunctiva in these cases, and have regarded these organisms as the cause of the conjunctival affection. It seems now more probable that they are merely secondary to the xerosis.

The connection between night-blindness and xerosis conjunctivæ remains to be explained; but it is likely that they are both results of the one cause.

Acute night-blindness is often the result of long-continued dazzling by very bright sunlight, or of lengthened exposure to bright firelight (*e.g.*, in foundries), and it is probable that in many, if not in most, instances of this affection, defective nutrition of the system plays the chief *rôle* in rendering the patients liable to it. Thus, in scorbutus, acute night-blindness has been frequently seen, when the patients have been exposed to strong glares of sunlight.

Treatment consists in protection from light,—in short, in complete darkness for a time,—and then gradual return to ordinary daylight; while the system is to be strengthened by careful dietary and suitable tonic medicines, especially cod liver oil.

Uræmic Amblyopia.—This is most commonly seen in connection with the nephritis of pregnancy and scarlatina, but may occur in any case of uræmic poisoning. It is met with in the acute forms of nephritis, in which albuminuric retinitis is not so liable to occur. The blindness is usually absolute, and may come on suddenly, or with a short previous stage of dimness of vision. It lasts from twelve hours to two or three days, and may recover completely, but in some cases a central scotoma remains.

The *Ophthalmoscopic Appearances* are negative.

Treatment can only be directed to the general condition.

The Prognosis for vision is good, as it always recovers if the patient's life be spared.

Pretended Amaurosis.—Malingerers rarely pretend total blindness of both eyes, and such cases can often only be detected by constant observation of their actions.

Presence of pupillary reflex is no proof that the patient sees, for this would be quite compatible with a cortical lesion causing total loss of sight (p. 415).

The crossed diplopia test (*vide infra*) may be employed in these cases; for if both eyes see, the one with the prism will rotate inwards for the sake of single vision, while if both eyes be blind, of course no such motion will take place. Again, if the malingerer's own hand be placed in various positions, and he be asked to look at it, he will in all probability look in some other direction; whereas a truly blind man usually makes a fair attempt at directing his eyes towards his own hand.

Pretended monocular amaurosis can generally be detected by the Diplopia Test. If the malingerer be made to look, with both eyes open, at a lighted candle placed some feet off, while a prism with its base downwards is held before the admittedly good eye, he will say he sees two images of the light one over the other. Were he blind of one eye he would not see two images.

Another method—the Crossed Diplopia Test—consists in holding a prism of some 10° or 12° with its base outwards before the pretended blind eye, when, if it sees, it will make a rotation inwards for the sake of single vision, an effort which a blind eye would not make.

Alfred Græfe's Method.—In this test the pretended blind eye is covered with the surgeon's hand from behind the patient, while with the other hand a prism (about 10°) is held base down before the good eye, so that its edge may pass horizontally across the centre of the pupil. Monocular double vision results, as the rays pass through the upper part of the pupil normally, while through the lower part of it they are refracted downwards by the prism. The double images stand over each other. If now the hand which excludes the pretended blind eye be rapidly removed, while at the same moment the prism is moved upwards, so that the entire pupil is covered by it, a malingerer will still see double images standing one over the other; for now the diplopia must be binocular.

Harlan's Test consists in placing a trial frame on the patient's nose with a very high + lens—say + 14 D—opposite the good eye, by which means it is excluded from distant vision, and a plane glass—or a 0·25 D convex or concave lens, which of course would not materially interfere with its distant vision—opposite the pretended blind eye. The patient then, believing there is much the same kind of glass before each eye, will read the test-types ; and if it be now desired to expose the deception, the pretended blind eye is excluded from sight, and the malingerer will then be unable to read the test-types.

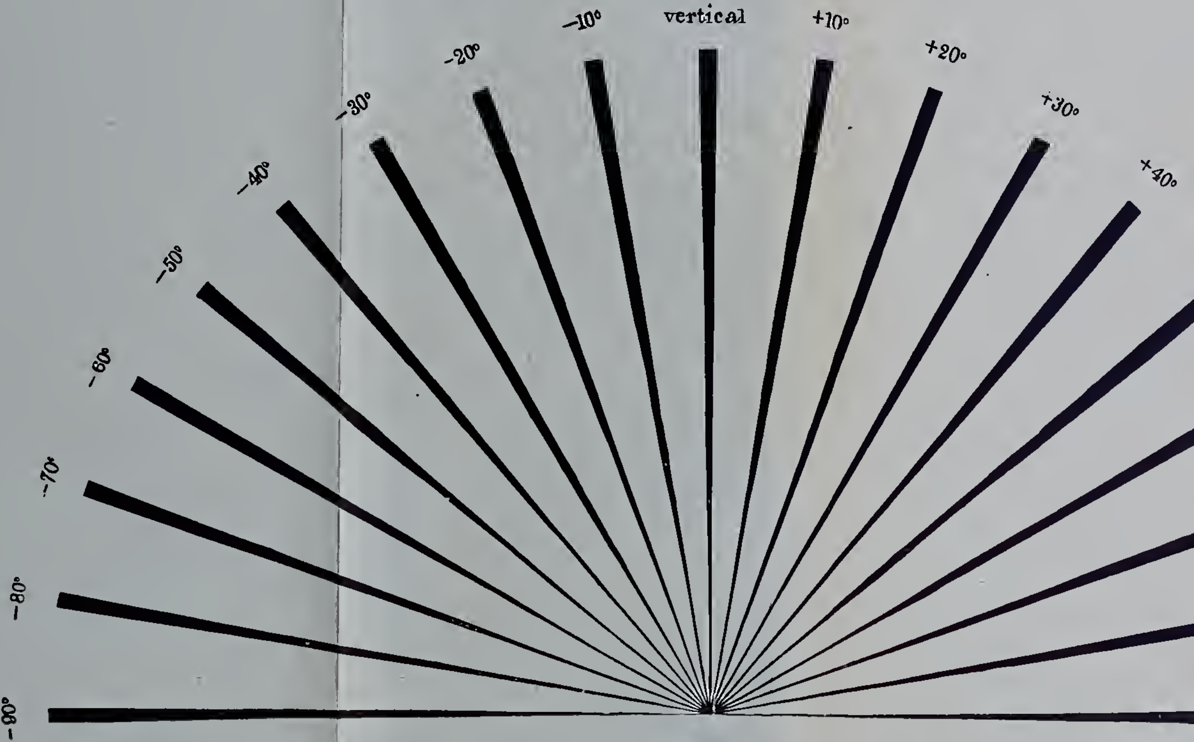
Snellen's Coloured Types may also be used for this purpose. These types are printed in green and red. If a person be really blind of one eye, he will, of course, see both the green and the red letters with the good eye. But if a green glass be held before the good eye, the rays from the red letters will be excluded, and he will now only see the green letters ; or with a red glass the red letters alone will be seen. A malingerer may be detected by holding before his admittedly good eye a green glass ; and if he now still see the red letters, it must be that he does so with the so-called blind eye.

It is well to have this variety of tests, in order that they may be used to corroborate each other.

Erythropsia (*ἐρυθρός, red*)—**Red Vision.** A large number of cases of this remarkable affection are on record ; indeed, it will have come under the notice of nearly every ophthalmic surgeon of any experience. Two-thirds of the cases have been subjects of successful cataract operations, whilst the remainder have possessed normal eyes. In some cases the red vision remains only a few minutes, and does not again return ; whilst in others it appears every day for a short time, for weeks or months ; and, again, in others it continues for several days, and then disappears for good or recurs at intervals. In the aphakic cases it does not usually appear for weeks or months after the removal of the cataract, and in one case the interval was two years. During the attacks the patients see all objects of a deep red colour, and occasionally of a purple or violet hue. In no instance is the acuteness of vision affected either during or after the attacks.

A satisfactory explanation for the affection has not yet been offered. It seems probable that it is due to over-excitation of the visual nervous apparatus—some believe of the visual centre, others of the retina—set a-going by exposure of the retina to strong light, along with other favouring circumstances, especially general over-excitement of the body or mind. More than this cannot at present be said.

Treatment seems to have but little effect. Protection of the eyes from light has not been of use. Bromide of potassium internally seems to have done some good in those cases where it was tried.


-90°
-80°
-70°
-60°
-50°
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-20°
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+40°

APPENDIX I.

HOLMGREN'S METHOD FOR TESTING THE COLOUR-SENSE.

For the purposes of this method a selection of Berlin worsteds is made, including red, orange, yellow, yellow-green, pure green, blue-green, blue, violet, purple, pink, brown, grey; several shades of each colour being present, and at least five gradations of each tint, from the deepest to the lightest. Green and grey, several kinds each of pink, blue, and violet, and the pale grey shades of brown, yellow, red, and pink must be well represented. But no two samples are to be of precisely the same shade of the same colour. This large number of colours and shades is used because the colour-blind person escapes detection with more difficulty, and the diagnosis therefore is all the more certainly made, the greater the variety of colours. The normal-eyed individual readily selects the right ones from the mass; whilst the colour-blind person, although the right ones are directly before him, picks out wrong ones, thereby disclosing the character of his defect.

The test-colour with which the examination invariably begins is a pale pure green, because green is the whitest of the spectral colours, and, consequently, the one in which the presence of colour is most difficult to recognise—the one, in short, most easily mistaken for grey (= no colour). We all experience the most difficulty in deciding whether there be any colour at all present in the very deepest shades (nearly black), and in the very palest shades (nearly white); therefore it was plainly either a very dark or a very pale shade of green that should be employed, and Holmgren's experience made him decide for the pale shade, as providing the most delicate test.

As a test for the diagnosis of the particular kind of colour-blindness, Holmgren recommends a purple (deep pink) sample—that is, the whole group of colours in which red (orange) and blue (violet) are combined in nearly equal proportions, or at least in such proportions that no one of them sufficiently preponderates over the others, to the normal colour-sense, so as to give its name to the combination. Purple is of especial importance in the examination of the colour-blind, for the reason that it forms a combination of two fundamental colours (red and blue)—

the two extreme colours—which are never confounded with each other.

The Method of Examination and of Diagnosis is as follows:—The worsteds are placed in a pile on a table in broad daylight. The test skein (pale pure green) is taken from the pile, and laid at a short distance from it, so as not to be confounded with the other skeins during the trial; and the person examined is then requested to select other skeins most resembling this in colour, and to place them by the side of the sample. It is necessary he should have clearly understood what is required of him—namely, that he should search the pile for the skeins making an impression on his chromatic sense similar to that made by the sample, and independently of any name he may give the colour. Indeed, it is not desirable that he should be asked to name the colours, and he should be discouraged from doing so. The examiner should explain that resemblance in every respect is not necessary; that no two specimens are just alike; that the only question is the resemblance of colour; and that, consequently, he must endeavour to find something lighter and darker of the same colour. If the person examined cannot understand this verbal explanation, the examiner must resort to action He must himself make the trial by searching with his two hands for the skeins, thereby showing what is meant by a shade, and afterwards restoring the whole to the pile, except the sample-skein. Or, when a large number of persons have to be examined together, it will be more rapid to begin at once with such a demonstration before the assemblage. There is no loss of security in this, for no one with defective chromatic sense finds the correct skeins in the pile any the more easily from the fact of having a moment before seen some one else looking for and arranging them.

On the card which is attached to the inside of the back cover of this book there are two classes of wool-samples. (1) The Test-Samples which are placed horizontally. (2) The Colours of Confusion—that is, those which the colour-blind person selects from the heap of wools, because he confuses them with the colour of the sample—and these are arranged vertically under their respective test-samples. The object of this card is merely to illustrate this text. It cannot itself be used for testing the colour-sense, nor does it contain all the colours and shades necessary for the purpose.

The test is conducted as follows:—*Test I.* The green sample is presented. This sample, as already explained, should be of the palest shade of very pure green, which is neither yellow-green nor blue-green to the normal eye, but fairly intermediate between the two. The examination must be continued until the person examined has selected all the other skeins of the same colour, or else, with these or separately, one or several skeins of the class corresponding to the "colours of confusion" (1 to 5), until he has sufficiently proved by his manner of doing it, that he can easily and unerringly distinguish the confusion colours, or until he has given proof of unmistakable difficulty in accomplishing his task. He who places beside the sample one of the colours of confusion (1 to 5)—that is to say, finds that it resembles the test-sample—is colour-blind. He who, without being quite guilty of this confusion, evinces a manifest disposition to do so, has a feeble chromatic sense.

If we want to know the kind and degree of the colour-blindness which the failure to perform *Test I.* shows to be present, we must proceed to

Test IIa.—A purple skein is shown to the person being examined. The trial must be continued until he has selected all, or the greater part of, the skeins of the same colour, or else, simultaneously or separately, one or several skeins of "confusion" (6 to 9). He who confuses, selects either the light or deep shades of blue and violet, especially the deep shades (6 and 7), or the light or deep shades of one kind of green or grey, inclining to blue (8 and 9). (1) He who is colour-blind by *Test I.*, and who, upon *Test IIa*, selects only purple skeins, is termed "incompletely colour-blind." (2) He who, in *Test IIa*, selects with purple only blue and violet, or one of them, is "completely red-blind." (3) He who, in *Test IIa*, selects with purple only green and grey, or one of them, is "completely green-blind." The red-blind never selects the colours taken by the green-blind, or *vice versâ.* Often the green-blind places a violet or blue skein beside the green, but only the brightest shades of these colours. This does not influence the diagnosis.

The examination may end here, and the diagnosis be regarded as settled. But to convince railway employers, and shipowners, and their employés, a still further trial may be made. It only serves to corroborate the diagnosis.

Test IIb.—The red skein is presented. It is necessary to have a vivid red colour, like the red flag used as signals on railways. This test, which is applied only to those either "completely red-blind" or "completely green-blind," should be continued until the person examined has placed beside the specimen all the skeins belonging to this shade, or the greater part of them, or else, separately, one or several "colours of confusion" (10 to 13). Alongside the red the red-blind person places green and brown shades, which (10 and 11) to the normal sense seem darker than red. On the other hand, the green-blind person selects opposite shades—those which appear lighter than red (12 and 13). Every case of complete colour-blindness discovered does not always make the precise mistakes just mentioned with *Test IIb.* These exceptions are either persons with comparatively inferior degrees of complete colour-blindness, or of colour-blind persons who have been exercised in the colours of signals, and who try not to be discovered.

They usually, but not always, confound at least green and brown. Total colour-blindness is extremely rare, but such a case would be recognised by a confusion of every colour having the same intensity of light.

Violet-blindness will be recognised by a genuine confusion of purple, red, and orange in *Test IIb.*

If further information on the subject be desired, the reader should consult Professor Holmgren's original monograph, "De la Cécité des Couleurs," Stockholm, 1877, or Dr. Joy Jeffries' "Colour-Blindness," Boston, 1879.

APPENDIX II.

REGULATIONS AS TO DEFECTS OF VISION WHICH DISQUALIFY CANDIDATES FOR ADMISSION INTO THE CIVIL, NAVAL, AND MILITARY GOVERNMENT SERVICES, THE ROYAL IRISH CONSTABULARY, AND THE MERCANTILE MARINE.

By an Army Circular issued by the War Office—

Candidates for Commissions in the Army are required to possess the following visual powers. These regulations apply to all branches of the service, including the Medical Department.

Snellen's Test Types are used for determining the acuteness of vision.

1. If a candidate can read D = 6 at 6 metres (20 English feet), and D = 0·6, at any distance selected by himself, with each eye, without glasses, he will be considered fit.

2. If a candidate can only read D = 24 at 6 metres (20 English feet) with each eye without glasses, his visual deficiency being due to faulty refraction, which can be corrected by glasses which will enable him to read D = 6 at 6 metres with one eye, and D = 12 at the same distance with the other eye, and can also read D = 0·8 with each eye without glasses, at any distance selected by himself, he will be considered fit.

3. If a candidate can read D = 6 at 6 metres with one eye, a higher defect than D = 24 will be accepted in the other; and if he can read D = 36 with the defective eye at the required distance, the defect being due to error in refraction which can be remedied by glasses so that he can read, D = 12, he will be considered fit.

4. If a candidate cannot read D = 24 at 6 metres (20 English feet)

with each eye without glasses, notwithstanding that he can read D = 0·6, he will be considered unfit.

Squint, or any morbid conditions, subject to the risk of aggravation or recurrence in either eye, will cause the rejection of a candidate.

Inability to distinguish the principal colours will not be regarded as a cause for rejection, but the fact will be noted in the report, and the candidate will be informed.

The Royal Navy.—1. A candidate is disqualified unless both eyes are emmetropic. The candidate's acuteness of vision and range of accommodation must be perfect.

2. A candidate is disqualified by any imperfection of his colour-sense.

The author has it on good authority, that no absolute rule as to vision is laid down with regard to candidates for entry into the Navy Medical Service. Each case is determined at the physical examination at the Naval Medical Department, which takes place shortly before the competition.

Full normal vision is not necessarily essential in all cases for Naval Medical officers.

3. Strabismus, or any defective action of the exterior muscles of the eyeball, disqualifies a candidate for the Royal Navy.

The Home Civil Service.—Blindness or defective vision, except a moderate degree of ordinary shortsight, disqualify. But candidates for the Customs Outdoor Service must not be shortsighted.

The Indian Civil Service (*Covenanted and Uncovenanted*).—1. A candidate may be admitted into the Civil Service of the Government of India if ametropic in one or both eyes, provided that, with correcting lenses, the acuteness of vision be not less than $\frac{6}{9}$ in one eye and $\frac{6}{6}$ in the other, there being no morbid changes in the fundus of either eye.

2. Cases of myopia, however, with a posterior staphyloma, may be admitted into the service, provided the ametropia in either eye do not exceed 2·5 D, and no active morbid changes of chorioid or retina be present.

3. A candidate who has a defect of vision arising from nebula of the cornea is disqualified if the sight of either eye be less than $\frac{6}{12}$; and in such a case the acuteness of vision in the better eye must equal $\frac{6}{6}$, with or without glasses.

4. Paralysis of one or more of the exterior muscles of the eyeball disqualifies a candidate for the Indian Civil Service. In the case of a candidate said to have been cured of strabismus by operation, but without restoration of binocular vision, if with correcting glasses the vision reach the above standard (1), and if the movement of each eye be good, the candidate may be passed. The same rule applies to the case of unequal ametropia without binocular vision, both eyes having full acuteness of vision with glasses, and good movement.

The Indian Marine Service (*Including Engineers and Firemen*).—1 A candidate is disqualified if he have an error of refraction in one or both eyes which is not neutralised by a concave, or by a convex 1 D lens, or some lower power.

2. A candidate is disqualified if he cannot distinguish the primary colours and their various shades—red, green, violet or blue, and yellow.

3. Strabismus, or any defective action of the exterior muscles of the eyeball, disqualifies a candidate for the Marine Service.

Royal Irish Constabulary.—Candidates for cadetships in the Royal Irish Constabulary and recruits must be able to read with each eye separately, and without glasses, Snellen's metrical test types number D = 10, at 20 English feet, and those numbered D = 0·8 at any distance selected by the candidate himself.

Squint, inability to distinguish the principal colours, or any morbid condition, liable to the risk of aggravation or recurrence in either eye, will involve the rejection of the candidate.

The British Mercantile Marine.—An Appendix (Exn. 1, Appendix T) to the regulations relating to the Examinations of Masters and Mates in the Mercantile Marine has been issued by the Board of Trade, and came into force on September 1st, 1894.

It is entitled "Form Vision, Colour Vision, and Colour Ignorance Tests," and enacts the following rules:—

1. Examinations for Form Vision, Colour Vision, and Colour Ignorance are open to all persons serving or intending to serve in the Mercantile Marine, and all such persons are recommended to take the earliest opportunity of ascertaining by means of these examinations whether their vision is such as to qualify them for service in that profession.

2. The examination consists of three parts:—

(*a*) Form Vision Test; (*b*) Colour Vision Test; (*c*) Colour Ignorance Test.

No candidate will be examined in the Colour Vision Test until he has passed the Form Vision Test, or in the Colour Ignorance Test until he has passed the Colour Vision Test.

3. Any person serving or intending to serve in the Mercantile Marine, if desirous of undergoing the Form Vision, Colour Vision, and Colour Ignorance Test *only*, must make application to the Superintendent of a Mercantile Marine Office on the Form Exn. 2a, and must pay a fee of One Shilling.

4. Every candidate for a Certificate of Competency who is not already in possession of such a Certificate will be required to pass the three tests mentioned in Rule 2 before he can proceed to the examination in Navigation and Seamanship for the Certificate which he desires to obtain, even though he may have passed the tests on some previous occasion.

5. Every candidate who is already in possession of a Certificate of Competency, and who desires to obtain a Certificate of a higher grade, will be required to pass the three tests mentioned in Rule 2 before he can proceed to the examination in Navigation and Seamanship for the Certificate of a higher grade.

That is to say, no Candidate will be permitted to proceed with the examination in Navigation and Seamanship for a higher Certificate if he fail to pass the three tests.

6. If a Candidate fail to pass any of the three tests, a note of the fact of his having done so will be written across the face of the Certificate which he already possesses before the Certificate is returned to him.

7. If a Candidate who undergoes the Form Vision, Colour Vision, and Colour Ignorance Tests *only* (See Rule 3) be in possession of a Certificate of Competency, he must hand in his Certificate before the examination commences, and if he fail to pass any of the three tests, a statement of his failure will be written on the Certificate before it is returned to him.

8. Candidates who fail to pass the Form Vision Test or Colour Ignorance Test can be re-examined at intervals of three months, but candidates who fail to pass the Colour Vision Test cannot be re-examined. It is open, however, to any candidate who has failed to pass that test to appeal to the Board of Trade, who may, if they think fit, remit the case to a special examiner or body of examiners for final decision.

9. The expenses of candidates who are examined by the special examiners, *and are reported by them to have passed the three tests*, will, under certain circumstances, be paid by the Board of Trade, at a rate which will be notified to the candidate, but no payment whatever will be made towards the expenses of candidates who upon their own application are examined by the special examiners and are reported by them to have failed. The special examinations will be held in London only.

10. When a Candidate fails to pass the Colour Test the Examiner will point out to him the conditions under which he can appeal. Appeals are to be made through the Examiner, and forwarded to the Board of Trade with the Examiner's remarks.

11. The holder of a Certificate which bears on it a statement of failure in the first test (Form Vision) or in the third test (Colour Ignorance) can have the statement removed by passing after the prescribed interval the test to which it refers, but the instruction in the last paragraph of Rule 2 must be followed.

12. The fee paid for examination for a Certificate of Competency includes the fee of One Shilling for examination in Form Vision, Colour Vision, and Colour Ignorance, and if the candidate fails to

pass those tests, will, with the exception of One Shilling, be returned to him.

13. Only Examiners who have themselves passed the Colour Test are to undertake these examinations.

Form Vision Test.—The tests to be used are Snellen's Letter Test for candidates who can read, and the dot tests for those who cannot read. The sets of tests which have been supplied to the examiners consist respectively of eight sheets of Snellen's letters and two sheets of dots.

Candidates may use both eyes or either eye when being tested, but they must not be allowed to use spectacles or glasses of any kind. If the candidate can read correctly, at a distance of sixteen feet, three of the five letters in the fifth line from the top, or four of the letters in either of the two lines below, he may be considered to have passed the test. If he cannot do so he should be treated as having failed.

If the candidate cannot read he must be tested with the sheet of dots. For this test he is to be placed at a distance of precisely eight feet from the test sheets, and exactly opposite them. One of the sheets of dots is then to be exposed, and the candidate should be asked to name the number of dots in one or two of the lines or groups. Lines and groups of dots can be formed by holding a piece of white paper over part of the sheet, but care must be taken that when this is being done the candidate's view is not obstructed or the light on the test sheet in any way obscured.

If the candidate answer the questions put to him by the examiner with complete or very nearly complete accuracy, he should be treated as having passed. If he does not answer with very nearly complete accuracy, he should be treated as having failed.

Colour Vision Test.—The Colour Vision of candidates is to be tested by means of Holmgren's wools.

Colour Ignorance Test.—The object of this test is simply to ascertain whether the candidate knows the names of the three colours—red, green, and white—which it is important for every seaman to be acquainted with, and the test is to be confined to naming those colours.

One or two of the purest red and green skeins should be selected from the set of wools, and the candidate should be required to name their colours. He should also be required to name the colour of any white object, such as a piece of white paper.

If he answer correctly, he should be considered to have passed the test. If he make any mistake, he should be tried with the lantern which was formerly used for colour tests, the plain glass, and the standard red and green glasses being employed for the purposes. If he does not name these glasses correctly, he should be reported as having failed to pass the test.

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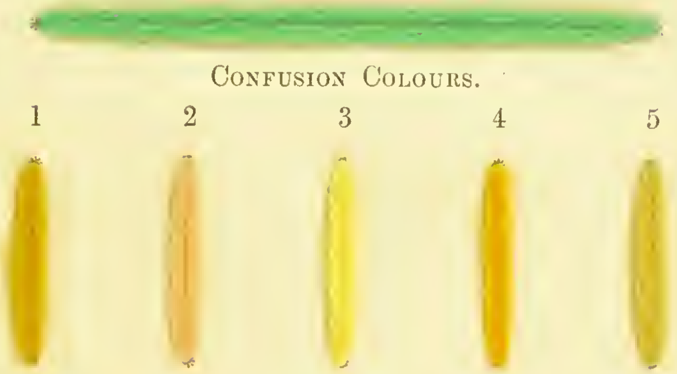

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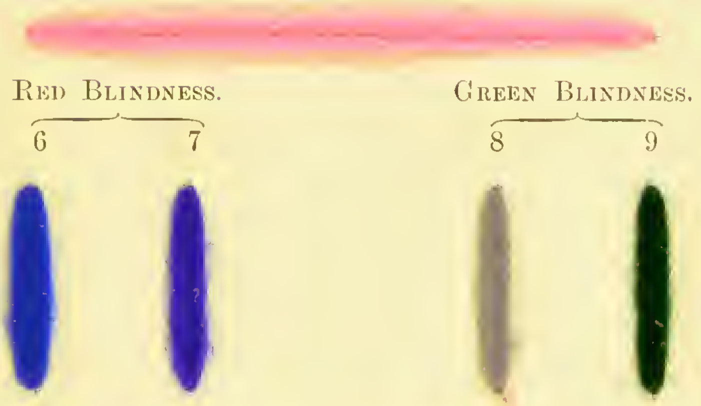

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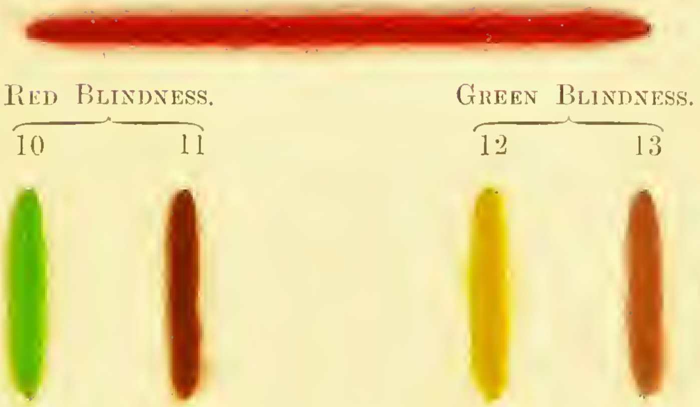

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